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ESSENTIALS

OF

CHEMISTRY

AND

TOXICOLOGY

FOR THE USE OF STUDENTS IN MEDICINE

BY

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PREFACE TO THE PRESENT EDITION.

THE present edition is practically a new work; the author having been prevented by force of circumstances from making a revision of the first edition for so long a period that the advances in chemical science have necessitated the re-writing of many portions, the re-arrangement of others, and the introduction of much new matter.

The title of the book has been somewhat modified in consequence of the introduction of the portions concerning Toxicology.

No physics have been introduced, as it is the opinion of the author that the applications of that science to medicine are distinct from those of chemistry, and are of sufficient importance to warrant separate treatment.

The author begs most distinctly to disclaim any desire to produce a "cram compend," and to state that his endeavor has been to so frame the questions as to render the work useless for such a purpose. The intent has been to offer to students and teachers of chemistry in medical colleges an aid to *systematic* quizzing, as an adjunct to a regular course of lectures upon the subject.

R. A. W.

61 Fifth Avenue,
Feb. 19*th*, 1888.

PREFACE TO THE FIRST EDITION.

THIS little volume is designed to fill a vacancy hitherto left unoccupied by chemical writers; many valuable text-books have appeared within the past few years, none of these, as far as I am aware, are designed for or adapted to the special needs of the American medical student, and all are more or less overburdened with descriptions of technical and pharmaceutical processes which are of no direct importance to the practitioner in medicine. In the following pages I have omitted all topics which are not "essential" to an understanding of those chemical problems which have a direct bearing upon the practice of medicine; more attention has been directed to the chemistry of therapeutics than to that of pharmacy, while physiological chemistry, which must now be regarded as one of the most important foundations of rational medicine, has been treated of as fully as the limits of the volume will permit.

The modern system of notation has been adopted, and the principles of the atomic theory have been dealt with in such a manner as, it is hoped, will afford the student a firm groundwork for future study.

It has not been my intention to write a manual of analytical chemistry, as those already at the command of the student leave nothing to be desired; I have, therefore, given only such analytical processes as the physician may reasonably expect to make use of in the course of his daily practice.

Weights and measures are given in the metric system, and temperatures in degrees of the Centigrade scale.

R. A. W.

New York, *Oct.*, 1878.

ESSENTIALS OF CHEMISTRY
AND
TOXICOLOGY.

INTRODUCTION.

1. *How do physical and chemical phenomena differ from each other?*

In the former the composition of the matter acted on remains unchanged, while in the latter it is altered; thus, when a cylinder of lime is strongly heated it becomes white hot and emits light; it is still lime, however, after the action of the heat, as it was before. This is a physical phenomenon. If now we throw this lime into hydrochloric acid it disappears, and, after the action has been completed, we find neither lime nor hydrochloric acid, but two new substances, one a solid, called calcic chloride, the other a liquid—water; both of which differ in their composition from the original substances, which have disappeared. This is a chemical phenomenon.

2. *What is chemistry?*

It is that branch of science which treats of the composition of substances, their changes in composition, and the laws governing such changes.

3. *How may we classify all matter?*

Into elements and compounds.

4. *What is an element?*

A kind of substance which we cannot, by any known means, split up into any two or more other kinds of substance; as iron, charcoal, oxygen. Elements are also called elementary or simple substances.

5. *What is a compound?*

A substance made up of two or more elements in definite proportions: as water, sulphuric acid, potash.

6. *How many elements are now known?*

Sixty-six.

7. *What is an atom?*

The smallest quantity of an elementary substance that can enter into chemical action.

It is therefore improper to speak of an atom of a compound substance.

8. *What is a molecule?*

The smallest quantity of any substance that can exist in a free state. Molecules nearly always contain two or more atoms; in molecules of elementary bodies these atoms are of the same kind, while in compound substances they are of different kinds, thus: The molecule of hydrogen is made up of two atoms of hydrogen, while the molecule of hydrochloric acid is made up of one atom of hydrogen united with one atom of chlorine.

9. *What are chemical symbols?*

Signs by which the elementary substances are expressed in chemical writing. The symbol of an element is generally the first (capital) letter of its Latin name, usually followed by one of the small letters; thus the symbol of of hydrogen is H, that of chlorine Cl, and that of carbon C.

10. *Does the symbol express a definite or an indefinite quantity of the element?*

A very definite quantity, namely, one atom.

11. *What is a formula?*

A collection of symbols representing a molecule and expressing the number and kinds of atoms of which it is constituted; thus HCl is the formula of hydrochloric acid, and expresses that its molecule is composed of one atom of hydrogen and one atom of chlorine; H_2O is the formula of water, and shows that its molecule is composed of two atoms of hydrogen and one atom of oxygen.

12. *What is a chemical equation?*

An expression by means of symbols, numbers, and signs of a chemical action. The sign + is used as the equivalent of the word "and," and the sign = indicates that the substances whose formulæ are placed before it have acted upon each other (have "reacted") to produce the substances whose formulæ follow the sign, thus, the equation,

$$CaO+2HCl=CaCl_2+H_2O$$

indicates that one molecule composed of one atom of calcium and one atom of oxygen, and two molecules, each composed of one atom of hydrogen and one atom of chlorine, have acted upon each other. This action has produced one molecule composed of one atom of calcium and two atoms of chlorine, and one molecule composed of two atoms of hydrogen and one atom of oxygen. As matter cannot be lost or created, the same number of each kind of atom must occur before and after the = sign.

13. *What is the atomic weight of an element?*

The weight of one of its atoms as compared to the weight of an atom of hydrogen; thus, an atom of hydrogen weighing 1, an atom of oxygen weighs 16, an atom of sulphur 32, and an atom of chlorine, 35.5. This weight is relative and not absolute. What the absolute weight of an atom of hydrogen may be we do not know.

14. *What is molecular weight?*

The weight of the molecule of any substance, *i.e.*, the sum of the weights of the atoms constituting its molecule; thus, the molecules of hydrogen being composed of two atoms, H_2, its molecular weight is 2; hydrochloric acid being composed of one atom of hydrogen and one of chlorine, its molecular weight is $1+35.5=36.5$.

15. *State the law of definite proportions.*

The relative weights of elementary substances contained in a compound are definite and invariable, *e.g.*, water contains 2 parts by weight of hydrogen and 16 parts of oxygen, never more and never less.

16. *State the law of multiple proportions.*

When two elements unite with each other to form more than one compound, the resulting compounds contain simple multiple proportions of one element as compared to a constant quantity of the other, *e.g.*, nitrogen and oxygen unite with each other to form five compounds, in which for 28 parts by weight of nitrogen there is contained 16 parts by weight of oxygen, or some simple multiple of 16:

Nitrogen	monoxide	contains	28	p'ts	nitrogen &	16	oxygen
"	dioxide	"	28	"	"	$16\times2=32$	"
"	trioxide	"	28	"	"	$16\times3=48$	"
"	tetroxide	"	28	"	"	$16\times4=64$	"
"	pentoxide	"	28	"	"	$16\times5=80$	"

17. *What is a compound?*

A substance made up of two or more elements, united with each other in definite proportions.

The properties of a compound are properties of its own and independent of those of the constituent elements. Thus, the properties of water are entirely different from those of the constituent gases, oxygen and hydrogen.

To separate the elements of a compound a chemical decomposition is necessary.

18. *What is a "mixture"?*

A substance composed of two or more elements or compounds mingled together in any proportion.

The properties of a mixture are an aggregation of the properties of its constituents.

The substances composing a mixture may

frequently be separated from each other by simple, physical means.

E. g. A mixture of sugar and chalk is sweet; the sugar remains soluble in water and may be separated from the insoluble chalk by washing with water. The chalk and sugar are each capable of the same chemical actions while in the mixture as when free.

19. *State the law of reciprocal proportions.*

The ponderable quantities in which substances unite with the same substance express the relation, or a simple multiple thereof, in which they unite with each other.

E. g. Forty parts of calcium combine with 35.5 parts of chlorine, and 40 parts of calcium combine with 16 parts of oxygen, therefore 35.5 parts of chlorine combine with 16 parts of oxygen.

20. *State the laws of Gay Lussac.*

1. There exists a simple relation between the volumes of gases which combine with each other.

2. There exists a simple relation between the sum of the volumes of the constituent gases and the volume of the gas formed by their union.

1 vol. chlorine + 1 vol. hydrogen = 2 vols. hydrochloric acid.

1 vol. oxygen + 2 vols. hydrogen = 2 vols. vapor of water.

1 vol. nitrogen + 3 vols. hydrogen = 2 vols. ammonia.

21. *State the law of Avogadro.*

Equal volumes of all gases, under like conditions of temperature and pressure, contain equal numbers of molecules.

This is also known as the law of Ampère.

22. *By the preceding laws and the results of experiment prove that, if the atom of hydrogen weighs one, that of oxygen weighs sixteen, and that of chlorine thirty-five and a half.*

It may be shown by experiment that hydrogen combines with chlorine and oxygen in the following proportions by volume:

1 vol. chlorine + 1 vol. hydrogen = 2 vols. hydrochloric acid.

1 vol. oxygen + 2 vols. hydrogen = 2 vols. water vapor.

If equal volumes contain equal numbers of molecules,

1 molecule chlorine + 1 molecule hydrogen = 2 molecules hydrochloric acid.

1 molecule oxygen + 2 molecules hydrogen = 2 molecules water.

As each molecule of hydrochloric acid contains chlorine and hydrogen, the molecules of chlorine and hydrogen must each contain two quantities smaller than the molecules, *i. e.*, two atoms. Therefore

2 atoms chlorine + 2 atoms hydrogen = 2 molecules hydrochloric acid.

2 atoms oxygen + 4 atoms hydrogen = 2 molecules water.

But the relations by weight in which the combinations occur are:

35.5 chlorine + 1 hydrogen = 36.5 hydrochloric acid.

16 oxygen + 2 hydrogen = 18 water.

Therefore, if one atom of hydrogen weighs one, an atom of chlorine weighs 35.5 and an atom of oxygen weighs 16.

23. *How is Avogadro's law utilized in the determination of molecular weights?*

The specific gravity of a gas (hydrogen = 1) is the weight of a given volume of the gas compared with the weight of an equal volume of hydrogen. It is therefore, under Avogadro's law, also the weight of a molecule of the gas as compared with the weight of a molecule of hydrogen; and as the unit of molecular weights is the atom, or half molecule of hydrogen, the molecular weight of the gas is its specific gravity (hydrogen = 1) multiplied by two.

24. *What is the "valence" of an element?*

The combining power of one of its atoms as compared with that of hydrogen.

Atoms of certain elements, such as chlorine, are found to be equal in combining power to those of hydrogen, *i. e.*, one atom of chlorine is equal to one atom of hydrogen; such elements are said to be *univalent.* Atoms of other elements, as oxygen, are found to be equal in combining power to two atoms of hydrogen; these are said to be *bivalent*; so other elements are said to be *trivalent*, *quadrivalent*, *quinquivalent*, *sexivalent*, as their atoms are equal in combining power to three, four, five, or six atoms of hydrogen. The valence of an element is expressed symbolically thus: $'$ univalent, $''$ bivalent, $'''$ trivalent, ^{iv} quadrivalent, ^{v}

quinquivalent, and vi sexivalent, the sign being placed over and to the right of the symbol of the element, thus: O'', P^{v}.

Elements are also classified as *monads*, *diads*, *triads*, *tetrads*, *pentads*, according as their valence is equal to one, two, three, four or five.

25. *What are* artiads *and* perissads?

Artiads are elements of even valence; *perissads* those of uneven valence.

26. *What is an acid?*

(1.) It is a compound of an electro-negative element or radical with hydrogen, which hydrogen it can part with in exchange for an electro-positive element, without formation of a base.

(2.) It is a compound which evolves water by its action upon pure caustic potash, or soda.

27. *What is the basicity of an acid?*

It is the number of replaceable atoms of hydrogen contained in its molecule.

Thus HNO_3 is *monobasic*, H_2SO_4 is *dibasic*, H_3PO_4 is tribasic.

Polybasic acids are those whose basicity is greater than one.

28. *What are* hydracids *and* oxyacids?

A hydracid is one containing no oxygen; as HCl. An oxyacid is one containing oxygen; as H_2SO_4.

29. *What is a* salt?

It is an acid whose hydrogen has been partially or completely replaced by an electro-positive element or elements (a metal or metals).

30. *What are haloid salts; what oxysalts?*

A haloid salt is a salt of a hydracid. An oxysalt is a salt of an oxyacid.

31. *What is a base?*

It is a substance which will produce a salt and water on contact with an acid.

32. *What is a metal?*

An element capable of replacing the hydrogen of an oxyacid to form a salt.

33. *How many salts of an univalent metal and a monobasic acid can exist?*

Only one; one atom of the metal is capable of replacing one atom of hydrogen, and the acid only contains one atom of H capable of being so replaced; *e. g.*, the only possible salt of sodium and nitric acid is sodium nitrate, $NaNO_3$.

34. *How are the salts of the monobasic acids with bivalent metals formed?*

An atom of the bivalent metal displacing two atoms of hydrogen, and the monobasic acids only containing one atom of replaceable hydrogen in each molecule, the formation of salts by these two substances is only possible when two molecules of the acid combine and the atom of bivalent metal replaces their united hydrogen, thus:

$$\underset{\substack{\text{Nitric acid}\\\text{(2 molecules).}}}{2HNO_3} + \underset{\text{Zinc.}}{Zn} = \underset{\substack{\text{Zinc.}\\\text{nitrate.}}}{Zn(NO_3)_2} + \underset{\substack{\text{Hydrogen}\\\text{univalent.}}}{H_2}$$

35. *How many salts may be formed by an univalent metal and a dibasic acid?*

Two. One in which only one of the atoms of hydrogen has been replaced by an atom of the metal, *e. g.*, $HNaSO_4$; and another in which both atoms of hydrogen have been replaced by atoms of the metal, *e. g.*, Na_2SO_4.

36. *What is understood by the reaction of a substance?*

All the acids and some salts have the power of reddening certain vegetable blue colors such as solution of litmus; these are said to have an acid reaction. Certain other substances, as the hydrates of sodium and potassium, have the power of restoring the blue color of litmus after it has been reddened by an acid; these substances are said to be alkaline in reaction. When a substance will neither redden litmus nor restore its blue color when reddened it is said to be neutral.

37. *How are compounds containing two, three, or four elements distinguished by name?*

A compound whose molecule contains two elements is called a *binary* compound, *e. g.*, H_2O; one containing three elements is called a *ternary* compound, *e. g.*, H_2SO_4; and one containing four elements is called a *quarternary* compound, *e. g.*, $KHSO_4$.

38. *What is the fundamental principle of modern chemical nomenclature?*

That the name shall indicate, so far as possible, the composition of the substance.

39. *How are the names of binary substances constructed?*

They are made up of the name of the more electro-positive, followed by the name of the more electro-negative, in which the termination *ine*, *or*, *ogen*, *ygen*, *orus*, *ium*, or *ur* is changed to *ide*; *e. g.*, the compound of potassium and chlorine is called potassium chloride; that of calcium and oxygen, calcium oxide; and that of sodium and sulphur, sodium sulphide.

40. *When more than one binary compound of the same two elements exist, how are they distinguished by name?*

By prefixing to the last word of the name, constructed as in No. 39, the Greek numeral corresponding to the number of atoms of the element designated by that word, as compared with a *fixed* number of atoms of the other element:

N_2O — Nitrogen *mon*oxide.
$NO(= N_2O_2)$ — Nitrogen *di*oxide.
N_2O_3 — Nitrogen *tri*oxide.
$NO_2(= N_2O_4)$ — Nitrogen *tetr*oxide.
N_2O_5 — Nitrogen *pent*oxide.

41. *How are the names of the oxyacids constructed?*

By writing the word *acid*, preceded by the name of the electro-negative element other than oxygen, in which the termination is modified, and to which a prefix is sometimes added, to indicate the degree of oxidation.

When but two acids exist, that containing the least amount of oxygen is designated by the termination *ous*; that containing the greater amount of oxygen by the termination *ic*, *e. g.*:

HNO_2 = Nitr*ous* acid,
HNO_3 = Nitr*ic* acid.

When more than two acids are known, that containing less oxygen than the *ous* acid is designated by the prefix *hypo*; that containing more oxygen than the *ic* acid by the prefix *per*, *e. g.:*

$HClO$ = *Hypo*chlor*ous* acid.
$HClO_2$ = Chlor*ous* acid.
$HClO_3$ = Chlor*ic* acid.
$HClO_4$ = *Per*chlor*ic* acid.

In the cases of the acids of sulphur and of phosphorus (q. v.) derived acids exist, which are differently named.

42. *How are the names of oxysalts derived from those of the corresponding acids when the valence of the metal equals the basicity of the acid?*

By prefixing to the name of the acid that of the metal, changing the termination *ous* into *ite*, or *ic* into *ate*, and expunging the word *acid:*

HNO_2 Nitr*ous* acid.	$K'NO_2$ *Potassium* nitr*ite*.
H_2SO_4 Sulphur*ic* acid.	$Ca''SO_4$ *Calcium* sulph*ate*.

The salts of the hydracids being binary compounds are named in accordance with No. 39.

HCl Hydrochloric acid.	KCl Potassium chlor*ide*.

43. *How are the names of oxysalts derived from those of the acids when the valence*

of the metal and the basicity of the acid are unequal?

In the same way as in No. 42, except that the Greek numeral corresponding to the number of atoms of the metal in the salt is prefixed to the name of the metal, whose termination is also changed to *ic:*

H_3PO_4
Phosphor*ic* acid.

$K'H_2PO_4$
*Mono*potass*ic* phosph*ate*.

K_2HPO_4
*Di*potass*ic* phosph*ate*.

K_3PO_4
*Tri*potass*ic* phosph*ate*.

CLASSIFICATION OF THE ELEMENTS.

CLASS I. TYPICAL ELEMENTS.

Hydrogen—Oxygen.

CLASS II. ACIDULOUS ELEMENTS.

Elements whose oxides combine with water to form acids, never to form bases. Which do not displace the hydrogen of oxyacids to form oxysalts.

GROUP I. Fluorine, chlorine, bromine, iodine.
GROUP II. Sulphur, selenium, tellurium.
GROUP III. Nitrogen, phosphorus, arsenic, antimony.
GROUP IV. Boron.
GROUP V. Carbon, silicon.
GROUP VI. Vanadium, niobium, tantalium.
GROUP VII. Molybdenum, tungsten, osmium.

CLASS III. AMPHOTERIC ELEMENTS.

Elements whose oxides unite with water, some to form acids, others to form bases. Which form oxysalts.

Group I. Gold.
Group II. Chromium, manganese, iron.
Group III. Glucinium, aluminium, scandium, gallium, indium.
Group IV. Uranium.
Group V. Lead.
Group VI. Bismuth.
Group VII. Titanium, zirconium, tin.
Group VIII. Palladium, platinum.
Group IX. Rhodium, ruthenium, iridium.

CLASS IV. BASYLOUS ELEMENTS.

Elements whose oxides unite with water to form bases, never to form acids. Which form oxysalts.

Group I. Lithium, sodium, potassium, rubidium, cæsium, silver.
Group II. Thallium.
Group III. Calcium, strontium, barium.
Group IV. Magnesium, zinc, cadmium.
Group V. Nickel, cobalt.
Group VI. Copper, mercury.
Group VII. Yttrium, cerium, ytterbium, lanthanium, didymium, erbium.
Group VIII. Thorium.

See Manual, p. 26.

CLASS I. TYPICAL ELEMENTS.

HYDROGEN. H′. 1.

44. *What are the symbol, valence, atomic and molecular weights of hydrogen?*

Its symbol is H, it is univalent. The weight of one atom of hydrogen is the unit of atomic weights, the standard with which the atoms are compared. Its atomic weight is therefore 1. Its molecular weight is 2.

45. *How does H exist in nature?*

Free in volcanic gases, in fire damp, in meteorites, in the gases exhaled from the lungs and in those of the stomach and intestines. In combination in water, hydrogen sulphide, ammoniacal compounds and in many organic substances.

46. *How is it prepared?*

By the decomposition of water (which is a compound of hydrogen and oxygen). Either: 1. By the action of a galvanic current. 2. By certain metals having a great tendency to unite with oxygen, as sodium. 3. By the action of hot zinc or iron. 4. By the action of these metals (zinc or iron) on cold dilute sulphuric or hydrochloric acid. The last is the method which is usually resorted to. When obtained by this process, H is almost always contaminated with small quantities of other gases due to the presence of impurities in the zinc and acid used. When perfectly pure H is required it is better to resort to the decomposition of water by the battery. See Manual, pp. 37, 38.

47. *Write the equation representing the action between zinc and sulphuric acid.*

$$H_2SO_4 + Zn + xH_2O = ZnSO_4 + xH_2O + H_2$$

H_2SO_4	Zn	xH_2O	$ZnSO_4$	xH_2O	H_2
Sulphuric acid.	Zinc.	Water.	Zinc sulphate.	Water.	Hydrogen.

48. *State some of the principal physical properties of hydrogen.*

A gas, colorless, odorless, and tasteless. It is the lightest known substance, being about 14½ times lighter than air. One litre of hydrogen weighs at 0° C. and 760 mm. barometric pressure, Grm. 0.0896. It is exceedingly diffusible. At −140° (−229° Fah.) and 650 atmospheres pressure it forms a steel-blue liquid.

49. *What results when a flame is applied to pure hydrogen?*

The gas ignites and burns with a pale blue flame, producing little light, but much heat.

The product of the burning is water = H_2O.

50. *Is it a supporter of combustion or respiration?*

No. A taper introduced into a vessel of H is extinguished, the hydrogen itself burning at the mouth of the vessel. An animal introduced into an atmosphere of pure hydrogen dies, not from any active agency of the gas, but from lack of oxygen.

51. *Explain what takes place when certain oxides, as those of iron or copper, are heated in hydrogen.*

At elevated temperatures the oxygen has a greater tendency to unite with hydrogen than to remain combined with the other element, consequently the oxide is decomposed, water is formed and passes off as steam, while the metal remains.

$$\underset{\text{Cupric oxide.}}{CuO} + \underset{\text{Hydrogen.}}{H_2} = \underset{\text{Water.}}{H_2O} + \underset{\text{Copper.}}{Cu}$$

Such an action is called a *deoxidation* or a *reduction*, and any substance which, like hydrogen, has a tendency thus to remove oxygen from its compounds is said to be a *deoxidizing* or *reducing* agent.

OXYGEN. O''.16.

52. *What are the symbol, valence, and atomic and molecular weights of oxygen?*

O.—Bivalent—Atomic weight = 16. Molecular weight = 32.

53. *How is it prepared?*

By decomposing a compound rich in oxygen. Potassium chlorate is generally decomposed by heat, when oxygen is given off and potassium chloride remains. The chlorate is heated in a retort of difficultly fusible glass, or preferably, of metal, which should not be more than a third or half full; the gas is collected over water. By mixing with the chlorate an equal weight of manganese dioxide the liberation of oxygen takes place at a lower temperature. When this mixture is used care must be had that the manganese compound has not been adulterated, and that no organic matter is present. lest an explosion occur. The gas produced from this mixture must be washed by causing it to bubble through a solution of potash to separate a small quantity of chlorine which is formed. This precaution is essential if the gas is to be used for inhalation.

54. *State the more prominent physical properties of* O.

It is a colorless, odorless, tasteless gas; heavier than air (sp. gr. 1.108, air = 1). Sparingly soluble in water; more readily soluble in absolute alcohol. It liquefies at −140° (−229° F.) under a pressure of 300 atmospheres.

55. *Does* O *unite readily with other elements?*

Very readily, and compounds of oxygen wth all other elements except fluorine are known.

56. *What is a compound of O with another element called?*

An oxide.

57. *What is meant by oxidation and combustion?*

By oxidation we mean the act of union of oxygen with another element. This process, like all chemical union, is attended by the liberation of heat, and, when it takes place rapidly, of light. The rusting of a given weight of iron is a slow oxidation, while the burning of the same in oxygen is a rapid oxidation. Only the latter produces light, while in both cases the same amount of heat is liberated. By combustion, in a general sense, is meant the rapid union of the oxygen of the air with some other substance, as coal or phosphorus. In a wider sense, however, combustion may be defined as any chemical union of two substances attended by liberation of heat and light.

58. *What are meant by combustibles and supporters of combustion?*

By a combustible we understand a substance having a great tendency to unite rapidly with oxygen, such as phosphorus and sulphur. Such substances burn with greater brilliancy in pure oxygen than in air, which is oxygen in a diluted form. By supporters of combustion we mean gases with which substances of the last class enter into chemical action attended by light and heat.

59. *Is the distinction in the last section a scientific one?*

No. The process of combustion being a union of two substances, each of these takes an equal part in the reaction. The air or oxygen burns quite as much as the jet of house gas which we say burns; indeed we may light a jet of oxygen in an atmosphere of coal gas, when it will burn precisely as would a jet of coal gas in an atmosphere of oxygen.

60. *When we burn a candle what takes place, and how does the weight of the products compare with that of the candle?*

The substance of the candle is made up principally of two elements, carbon and hydrogen; which, uniting with the oxygen of the air, form compounds called carbonic anhydride and water. The former is an invisible gas and the latter passes off as steam. If, by a suitable arrangement, we collect and weigh these products of the combustion we find that their united weight is greater than that of the candle, and this increase in weight is equal to the weight of the oxygen which has been abstracted from the air and united to the carbon and hydrogen.

61. *Of what importance is oxygen in respiration?*

It is the only substance capable of maintaining the process for any length of time. The process of respiration is essentially an oxidation. The blood in the lungs gives off carbonic anhydride, which results from the combustion of carbon, and water, which results from the oxidation of hydrogen. At the same time, it removes oxygen from the air; this oxygen is then carried to the various tissues, composed largely of carbon and hydrogen; an oxidation takes place here with the production of carbonic anhydride and water, while heat is liberated.

62. *What is ozone?*

Oxygen in a peculiar condition of condensation; the molecule of oxygen is made up of two atoms, while that of ozone contains three.

63. *Under what conditions is ozone formed, and to what extent?*

By passing silent electric discharges through cold, dry air or oxygen; by the action of concentrated sulphuric acid on barium dioxide;

by slow oxidation of phosphorus in damp air; by the decomposition of water by the battery.

The first-mentioned method gives the best yield, which, under most favorable conditions, does not yield more than ten parts of ozone with ninety of oxygen.

64. *What are the properties of ozone?*

It is slowly converted into ordinary oxygen in the presence of water at 100° (212° F.), a change which takes place rapidly at 237° (459° F.). It is a powerful oxidant.

65. *Describe the tests for ozone.*

1. Neutral litmus paper, impregnated with solution of potassium iodide, is turned blue by ozone. The same paper, without iodide, is not affected.

2. Paper impregnated with a solution of a thallous salt is turned brown.

COMPOUNDS OF HYDROGEN AND OXYGEN.

66. *How many compounds of hydrogen and oxygen are known, and what are they?*

Two:

Hydrogen monoxide, or water,	H_2O
" dioxide, or oxygenated water,	H_2O_2

67. *What is meant by synthesis and analysis?*

By synthesis is meant the union of two or more simple substances to form a compound, and by analysis the division of a compound into its constituent elements.

68. *How can we prove by analysis that water has the composition H_2O?*

If we pass the current of a battery through acidulated water, the water is decomposed into its constituent gases, and, collecting these separately, we find one to be pure hydrogen and the other pure oxygen. For every one volume of oxygen collected we will obtain two volumes of hydrogen, and if we weigh these gases we will find that the hydrogen formed weighing 2, the oxygen will weigh 16, and as each atom of oxygen weighs 16, and each atom of hydrogen one, the molecule of water is composed of one atom of oxygen combined with two atoms of hydrogen, and its formula is consequently H_2O.

69. *How can we prove synthetically that the composition of water is* H_2O*?*

1. If we make a mixture of 2 volumes of hydrogen with 1 volume of oxygen, and pass through it an electric discharge, chemical union will take place, the gases will disappear entirely, and in their place will remain a small quantity of water. 2. If we burn hydrogen in an atmosphere of oxygen, and collect the result, we will find it to be water. If in No. 1 we use more than 2 volumes of hydrogen, or more than 1 volume of oxygen, the excess will remain after the union. This is in obedience to the law of definite proportions.

70. *What influence has temperature upon a mixture of oxygen and hydrogen?*

At the ordinary temperature a mixture of oxygen and hydrogen remains such indefinitely, no chemical union taking place; but if the temperature be raised, even at a single point in the mixture, as by applying a lighted match, or by the passage of an electric discharge, union takes place, and proceeds through the entire mass with great rapidity, causing a violent explosion. This influence of temperature upon chemical action is one of great importance, and not to be lost sight of, especially in animal chemistry, as certain actions take place at the temperature of the body which are arrested when the temperature is raised or lowered a few degrees.

71. *What precaution is to be observed in experimenting with hydrogen?*

Mixtures of hydrogen with oxygen or air, in certain proportions, explode on contact with with flame with great violence; care is therefore to be had that, before collecting the gas, all the air has been driven out of the apparatus; moreover, hydrogen should only be preserved in glass vessels (having no cracks) over water, as it is a very diffusible substance, and, if kept over night in rubber or metallic vessels, there is danger that air may pass in and form an explosive mixture. Neglect of these precautions has produced very serious accidents.

72. *Where does water exist in the animal economy?*

In all parts.

73. *What functions does water perform in the economy?*

In the liquid parts it holds the solids in solution (and it is of all liquids the best solvent we have); in the semi-solids it maintains the peculiar consistency of these parts. Many of the constituents of the body contain water as a part of their composition, and when this water is driven off, their condition becomes so altered as to render them entirely unfit for the performance of their functions.

74. *By what channels is water eliminated from the system, and how does the amount discharged compare with that ingested?*

It is discharged in the urine, perspiration, expired air, and fæces. The amount discharged is greater than that ingested, the excess being formed by the oxidation of the hydrogen contained in the organic matters of the body.

75. *What substances render a water unfit for drinking?*

1. An excess of solid matter, as in sea-water and the water of mineral springs. 2. An excess of organic matter. 3. Poisonous metals, as lead, copper.

76. *What is meant by organic impurity?*

Low forms of vegetable life; decomposing animal or vegetable matter; contamination from admixture of sewage or of discharges from tanneries and from certain factories.

77. *Give a rough method of detecting organic impurity.*

Put a pint of water into a *perfectly clean* quart bottle, cork and shake strongly, remove the cork, and inhale the air of the bottle. If the water be much contaminated, and if the observer's sense of smell be acute, an offensive odor will be observed.

NOTE.—This method is *quite* rough, and only very bad water will produce an odor; the best method of determining accurately to what extent a water is contaminated with organic matter is by the use of Wanklyn's process, which, unfortunately, is not adapted to the use of medical practitioners. See Manual, p. 47.

78. *What waters are most liable to organic contamination?*

That of stagnant pools. That of rivers having a sluggish stream or flowing through towns or manufacturing districts. That of wells.

NOTE.—Of course the water of stagnant pools is never used for drinking purposes, while it is only by criminal neglect on the part of the sanitary authorities that drinking-water is contaminated with the refuse of towns or factories. Well-water, however, especially that of shallow wells or those near which a drain-pipe passes, very frequently is the medium through which disease is communicated. Indeed the water of many wells situated near houses is simply diluted urine, holding fecal matter in suspension and solution. This condition of things is bad enough when the excreta are those of healthy individuals, but when a typhoid or cholera patient appears upon the scene, the result is invariably an epidemic. Medical practitioners cannot be too suspicious of the water supply under these conditions, and if not capable themselves of making an analysis, should condemn a suspected well absolutely until a proper examination of the water and of the drains has been made.

79. *What poisonous metal occurs most frequently and how may it be detected?*

Lead. Take two tumblers full of the water, place them upon a sheet of white paper, and add ammonium sulphydrate solution to one tumbler, and afterward hydrochloric acid. If the water to which the first reagent has been added becomes perceptibly darker than the other, and does not become colorless with hydrochloric acid, it is contaminated with lead or copper.

80. *What influence has the purity of water upon its power of dissolving lead?*

Perfectly pure, *unaerated* water has no action upon lead, and a bright strip of the metal will retain its lustre in it indefinitely; but if the water contain air in solution, the lead becomes oxidized, and the oxide dissolves in the water; the solvent power of the water being increased by the presence of chlorides or nitrates. If, on the other hand, the water hold in solution sulphates or carbonates or carbonic anhydride (commonly called carbonic acid gas) in small amount, its power of dissolving lead is very much diminished, because these form upon the surface of the metal a coating of lead sulphate or carbonate, which are compounds insoluble in water, and which protect the lead from any further action of the water.

81. *What practical indications may be drawn from the last answer?*

1. Rain-water should never be collected from roofs covered with lead, or in leaden tanks, because such water contains no fixed solids and is liable to contain nitric acid and nitrates; its solvent power for lead is therefore comparatively great. 2. A well or vessel for containing water should never have a leaden cover, because the water, evaporating from the surface, condenses upon the lead ln a very pure form, as far as solids are concerned, but highly aërated; it thus dissolves a portion of the oxi-

dized metal and, falling, carries it into the mass below.

82. *What are the physical characters of a good drinking water?*

It must be neither flat, salty, sweetish nor otherwise disagreeable in taste; cool, limpid, clear, odorless; and capable of dissolving soap without formation of a curdy precipitate.

N. B.—A water which does not fulfil those conditions is certainly unfit, one which does is not necessarily fit for drinking. See Manual, pp. 46–49.

83. *How may water be purified?*

By distillation and filtration. By the former method, which consists of converting the water into steam by the action of heat and condensing the steam, an almost absolutely pure water may be obtained, provided the vessels are of a material not acted on by water at the temperature attained, and provided no soluble gas be present. Unless very pure spring water be at hand, distilled water should be used in most chemical operations; and in toxicological analysis the distillation should be repeated at least twice and only new glass vessels used. Distilled water, although very pure, is by no means the best for drinking purposes, as, owing to the absence of air and carbonic anhydride, and probably also of a small quantity of mineral matter, it is flat in taste and difficult of digestion. Filtration is the method usually adopted for the purification of drinking-water, and consists in passing the water through a substance which retains any solid particles which may be held in suspension. If animal charcoal be used as the filtering medium, not only are particles in suspension arrested, but organic matter in solution is also, to a great extent, destroyed by oxidation. See Manual, p. 49.

84. *What is a hydrate?*

A substance derived from water by the substitution of an element or a radical* for a part of its hydrogen.

H_2O Water.	HKO Potassium hydrate.
$2H_2O$	CaH_2O_2 Calcium hydrate.

85. *What is the group (HO) called?*

Hydroxyl.

86. *What is water of crystallization, and what symbol is used to denote it?*

Many substances, upon assuming the crystalline form, take with them a definite number of molecules of water, which are necessary to the maintenance of the peculiar form, and frequently of the color, but which in no way modify the chemical properties of the substance. This is called water of crystallization, and is denoted by the symbol Aq. (Latin aqua = water).

$$Na_2SO_4,10Aq.$$

Sodic sulphate with 10 molecules water of crystallization.

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* See Q. 658.

87. *Explain the terms* anhydrous, deliquescent, *and* efflorescent.

A substance is *anhydrous* when it contains no water. A *deliquescent* substance is a solid that has such a tendency to unite with water that it absorbs it from the air, becoming damp, and finally fluid. Crystalline bodies are *efflorescent* when on exposure to air they lose their water of crystallization and fall to powder.

88. *In what way is the solubility of solids in water affected by variations in temperature?*

As a rule, the amount of a solid which a given volume can dissolve increases as the temperature is raised.

There are exceptions. Thus, common salt is nearly equally soluble at all temperatures. The solubility of disodic sulphate increases rapidly up to 33° (91.4° F.), and then diminishes nearly as rapidly at higher temperatures. A few solids, like the hydrate and citrate of calcium, are more soluble at low than at high temperatures. See Manual, p. 31.

89. *How is the solubility of gases in water influenced by variations in temperature and pressure?*

All gases are the more soluble the lower the temperature, and the greater the pressure.

90. *What is a saturated solution?*

One containing as much of the dissolved substance as can be dissolved at the existing temperature and pressure.

91. *Explain what is understood by* physical *and what by* chemical solution.

In a physical solution there is no modification of the solvent or substance dissolved. Such a solution on evaporation deposits a dissolved solid unaltered.

In chemical solution, the solvent and dissolved substance act upon each other to produce a new substance, which is then dissolved. Such a solution does not leave the substance originally dissolved when it is evaporated.

HYDROGEN DIOXIDE.—See Manual, p. 52.

CLASS II. ACIDULOUS ELEMENTS.

92. *What are the characteristics of the acidulous elements?*

Their oxides combine with water to form acids, never to form bases. They do not displace the hydrogen of oxyacids to form oxysalts.

93. *What name is sometimes used to designate the elements of this class?*

The metalloids.

94. *Name the principal elements included in this class.*

Chlorine, bromine, iodine, sulphur, nitrogen, phosphorus, arsenic, antimony, boron, carbon and silicon.

GROUP I. THE HALOGENS.

Fluorine	F	19
Chlorine	Cl	35.5
Bromine	Br	80
Iodine	I	127

94*a*. *Name the elements constituting the chlorine group.*

Fluorine, chlorine, bromine, iodine.

95. *Describe the common properties of the elements of this group.*

They are univalent. They form compounds with hydrogen, containing one volume of the element in the gaseous state combined with one volume of hydrogen, which are monobasic acids. Their hydrates are monobasic acids (fluorine forms no hydrate). They are all possessed of bleaching and disinfecting powers.

95*a*. *What name is applied to the group?*

The halogens.

FLUORINE.

95*b*. *What are the symbol, and atomic and molecular weights of fluorine?*

F 19, 38.

95*c*. *Has it been obtained in a free state?*

It has not.

96. *What compound of fluorine with hydrogen is known, and what are its uses and properties?*

Hydrofluoric acid or hydrogen fluoride, HF. A colorless gas, soluble in water, highly acid and corrosive. It is used either as gas or in solution for etching on glass, which it attacks with great energy.

97. *How is HF obtained, and what precautions are to be observed?*

It is prepared by the action of sulphuric acid upon a natural compound of F, called fluor spar:

$$\underset{\substack{\text{Calcium}\\\text{fluoride.}}}{CaF_2} + \underset{\substack{\text{Sulphuric}\\\text{acid.}}}{H_2SO_4} = \underset{\substack{\text{Calcium}\\\text{sulphate.}}}{CaSO_4} + \underset{\substack{\text{Hydrogen}\\\text{fluoride.}}}{2HF}$$

The operation must be performed in vessels of lead or of platinum.

Great care is to be had that the gas is not inhaled, and that the skin is not exposed to it, as, in a few instants, it produces painful blisters, afterwards forming open wounds which are very painful and heal with great difficulty.

CHLORINE.

98. *What are the symbol and atomic and molecular weights of chlorine?*

Symbol Cl, atomic weight 35.5, molecular weight 71.

99. *How does it exist in nature?*

It is not found free, but is very abundant in combination, notably in common salt.

100. *How is it prepared?*

There are three principal methods: 1. By the decomposition of its hydrogen compound (*i. e.*, muriatic acid) by black oxide of manganese:

$$MnO_2 + 4HCl = MnCl_2 + 2H_2O + Cl_2$$

MnO_2	$4HCl$	$MnCl_2$	$2H_2O$	Cl_2
Manganese dioxide.	Hydrochloric acid.	Managanous chloride.	Water.	Chlorine.

In this process 1 part of coarsely pulverized manganese dioxide is heated with 8 parts commercial muriatic acid. 2. By decomposition of common salt, 1 part of which, mixed with 1 part of finely powdered manganese dioxide, is heated with 8 parts commercial sulphuric acid. 3. A convenient, but not economical, process consists in heating to the temperature of boiling water 2 parts of potassium dichromate with 11 parts of commercial muriatic acid. When comparatively small quantities of Cl are required, it may be obtained by exposing chloride of lime moistened with water or with dilute acid; this is a convenient method when the gas is required for disinfection of limited spaces or for inhalation.

101. *State the more prominent physical properties of Cl.*

It is a greenish-yellow gas, having a very penetrating, suffocating odor, acting energetically upon the air-passages even when dilute, producing coughing, inflammation, and hæmoptysis. It is 2½ times heavier than air, and, as it is quite soluble in water, should be collected by allowing the delivery tube to reach to the bottom of a jar, whose opening is directed upwards, when the Cl collects from the bottom driving the air out above it.

102. *What is aqua chlori (U. S.) or liquor chlori (Br.)?*

A solution of Cl in water, saturated at the temperature of the air.

103. *Does Cl unite with other elements readily?*

It does. It unites directly with all elements except fluorine, oxygen, nitrogen, and carbon, and with these it frequently unites indirectly. This union of Cl with other elements is frequently attended by the appearance of light and heat: When a candle is burnt in Cl, the hydrogen of the candle unites directly with the Cl, giving off light and heat, while the carbon, being incapable of direct union with Cl, rises as a dense smoke.

104. *When chlorine and hydrogen combine what substance is formed?*

Hydrochloric acid.

105. *In what proportionate volumes do these two gases combine?*

In equal volumes.

106. *Under what conditions does the combination occur?*

A mixture of Cl and H may be kept indefinitely at ordinary temperatures and in the dark without union taking place. When the mixture is exposed to diffuse sunlight the combination takes place gradually, but if the mixture be exposed to the direct rays of the sun, or to certain strong artificial lights, or if a spark be passed through the mixture, combination occurs instantly with an explosion.

107. *What change takes place when a solution of Cl in H_2O is exposed to light?*

Under the influence of light Cl decomposes H_2O with formation of hydrochloric acid, while O is liberated:

$$\underset{\text{Water.}}{2H_2O} + \underset{\text{Chlorine.}}{2Cl_2} = \underset{\text{Hydrochloric acid.}}{4HCl} + \underset{\text{Oxygen}}{O_2}$$

108. *Why is the equation in the last answer not written*

$$H_2O + 2Cl = 2HCl + O?$$

Because that would indicate that a single atom of O could exist uncombined; atoms when liberated from one combination immediately combine with other atoms to form new molecules (See Q. 8).

109. *How does Cl act as a bleaching, deodorizing, and disinfecting agent?*

Indirectly as a powerful oxidizing agent; it decomposes the H_2O present, according to the equation given above, and the O, being in the nascent state, acts energetically. Cl will not bleach a perfectly dry substance.

110. *What is meant by the nascent state, and how is the superior energy of elements in this state explained?*

An element is said to be in the nascent state (the state of being born) at the instant that it is set free from one of its compounds. Free oxygen exists as a collection of molecules of oxygen, each molecule consisting of two atoms. When oxygen is liberated from a compound it is set free, first as individual atoms, these, however, not being capable of existing free, immediately unite in pairs to form molecules, but if at the instant at which oxygen is liberated there be present any substance with which oxygen has a great tendency to combine, its atoms enter into combination with this rather than with each other. As the force required to break up the molecule of oxygen is in this case not required, the combination takes place rapidly.

111. *What are the names and formula of the compound of chlorine and hydrogen?*

Hydrogen chloride or hydrochloric acid—HCl.

112. *What are the physical properties of this substance?*

It is a colorless gas; gives off thick white fumes on contact with moist air; has a very sharp penetrating odor, producing great irritation of the respiratory passages, and attacking the skin; reddens litmus; does not burn in air or support combustion; exceedingly soluble in water; heavier than air. Sp. gr. 1.293.

113. *What are the hydrochloric or muriatic acids of the arts and pharmacy?*

Solutions of this gas in water, of varying strength and purity.

114. *What varieties are there? Describe them.*

Commercial: A yellow liquid having usually a sp. gr. of about 1.16; contaminated with iron and chlorides of sodium and arsenic; used for manufacturing and rough chemical purposes.

Pure: Acidum hydrochloricum, U. S., Br. A colorless liquid, being a pure solution of HCl in water, of about the same strength as the last. Sp. gr. 1.16.

Acidum hydrochloricum dilutum, U. S., Br. The last named diluted with water, to sp. gr. 1.049 = 10 per cent HCl (U. S.); sp. gr. 1.052 = 10.5 per cent HCl (Br.)

115. *Name the three strong mineral acids?*

Hydrochloric, sulphuric, and nitric acids.

116. *What is the action of hydrochloric acid with a metallic oxide or hydrate?*

Both are decomposed, while water and a chloride are formed, thus:

$$\underset{\substack{\text{Calcium}\\\text{oxide.}}}{CaO} + \underset{\substack{\text{Hydrochloric}\\\text{acid.}}}{2HCl} = \underset{\substack{\text{Calcium}\\\text{chloride.}}}{CaCl_2} + \underset{\text{Water.}}{H_2O}$$

$$\underset{\substack{\text{Sodium}\\\text{hydrate.}}}{NaHO} + \underset{\substack{\text{Hydrochloric}\\\text{acid.}}}{HCl} = \underset{\substack{\text{Sodium}\\\text{chloride.}}}{NaCl} + \underset{\text{Water.}}{H_2O}$$

117. *What is* aqua regia?

A mixture of nitric and hydrochloric acids in the proportion of $1HNO_3$ to $3HCl$ or three parts by weight of nitric acid to 5 of hydrochloric. The acids react upon each other with liberation of Cl, which, being in the nascent state, combines with the noble metals, gold and platinum, if they be present, from which fact the name is derived; gold having been considered by the older chemists as the king of metals. The mixture is also known as nitrohydrochloric or nitromuriatic acid.

In the dilute form, it is used in medicine under the name *Acidum nitrohydrochloricum U. S., Br.*

118. *Describe the tests for the soluble chlorides and hydrochloric acid.*

1. With silver nitrate, a white, flocculent precipitate, insoluble in nitric acid, readily soluble in ammonium hydrate.

2. With mercurous nitrate, a white precipitate, turning black on addition of ammonium hydrate.

119. *What chlorides are insoluble or very difficultly soluble in water?*

Those of lead, silver, and mercury (calomel).

120. *How may they be distinguished from each other?*

By adding ammonia, if the substance be silver chloride it is dissolved, if it be mercurous chloride it turns black, and if be lead chloride it remains unaltered.

121. *Does free hydrochloric acid exist in the body?*

Yes. It is the free acid of the gastric juice.

122. *Define a poison.*

Any substance which, after absorption into the blood, produces death or serious bodily harm.

123. *Define a corrosive.*

A substance capable of producing death by its chemical action upon a tissue with which it comes in direct contact, without absorption by the blood.

The corrosives act upon dead and living tissues alike; the true poisons, as a rule, are without action upon the tissues after death.

124. *Are the mineral acids poisons or corrosives?*

They are corrosives. They are deleterious in consequence of their local action, and may cause death by contact with a large surface of skin as well as when taken into the stomach.

The action of the corrosives varies with the degree of *concentration,* which has no influence upon the action of the true poisons.

125. *Describe the prominent symptoms produced by the mineral acids.*

Acute, burning pain, extending from the mouth to the stomach, referred chiefly to the epigastrium, and beginning *immediately.* Violent and distressing vomiting of dark, tarry, or "coffee ground" and highly acid material. Eschars, at first white or gray, later brown or black are formed where the acid has come in contact with the skin, lips or tongue.

126. *How does death occur?*

Either within twenty-four hours from collapse; more suddenly from perforation and opening of large blood-vessels; or after several weeks or months from starvation, due to destruction of gastric cells or closure of the pylorus by inflammatory thickening.

127. *In what respects does hydrochloric acid differ from nitric and sulphuric in its action on the economy?*

The HCl gas, escaping from the solution, enters the air passages, and causes serious interference with respiration, dyspnœa, stridulous, frequent and moaning breathing, and loss of articulation.

128. *What should be the treatment in corrosion by mineral acids?*

The object is to neutralize the acid and convert it into a harmless salt. For this purpose, the best agent is magnesia (magnesia usta) suspended in a small quantity of water; or, if this be not at hand, a strong solution of soap. Chalk and the carbonates or bicarbonates of sodium potassium should *not* be given, as they generate large volumes of gas. The scrapings of a plastered wall are entirely useless. The stomach pump, or any attempt at the introduction of a tube into the œsophagus, is not to be thought of.

129. *Describe the post-mortem appearances caused by hydrochloric acid.*

The pharynx, larynx, and œsophagus, are highly inflamed; the mucous membrane sloughed off in places. The internal surface of the stomach is dark red or even black; the walls much thinned, or even perforated and softened. If death has resulted secondarily (see Q. 126), more or less of the stomach is found white or gray. and thickened, particularly at the pylorus, which may be so small as not to admit a fine knitting needle.

130. *What is a general characteristic of the compounds of chlorine with oxygen?*

They are all very unstable, being decomposed by very slight influences and frequently with explosion.

BROMINE.

131. *What are the symbol and atomic and molecular weights of bromine?*

Symbol = Br. Atomic weight = 80. Molecular weight = 160.

132. *What are its physical properties?*

It is a dark-brown liquid, giving off brown fumes freely when exposed to the air; has a strong, disagreeable odor, and is very irritating to mucous surfaces. It is sparingly soluble in water.

133. *How does bromine exist in nature?*

It is not found free, but exists in small proportion, widely diffused, however, in combination with potassium, sodium, and magnesium, in sea-plants, and in the waters of the sea and of certain mineral springs.

134. *How does bromine compare with chlorine in its chemical actions?*

Its actions are very similar to those of chlorine, but less intense; it forms compounds similar to those of chlorine, and is a good bleaching and disinfecting agent. Chlorine drives bromine out of its combinations; when a bromide is brought in contact with chlorine, a chloride is formed, while bromine is set free.

135. *Describe the tests for a bromide.*

1. With silver nitrate solution a yellowish-white precipitate, which is insoluble in nitric acid, soluble in a large excess of ammonium hydrate.

2. Add a few drops of chlorine water (to liberate the bromine), and then some chloroform; shake; the chloroform is colored yellow by bromine.

3. Repeat 2, using starch paste instead of chloroform; the liquid is colored yellow.

IODINE.

136. *Give the symbol and atomic and molecular weights of iodine.*

Symbol = I. Atomic weight = 127. Molecular weight = 254.

137. *How does it occur in nature?*

In the form of iodides in mineral waters, in sea water, and in animals and vegetables inhabiting the latter.

138. *Describe the principal physical properties of iodine.*

A blue-gray solid in scales, having a metallic lustre. Volatile at all temperatures, the vapor having a beautiful violet color and a peculiar odor. Fuses at 113°.6 C. (236°.5 F.) Dissolves readily in chloroform and in carbon bisulphide, forming violet-colored solutions; also in alcohol, forming a brown solution. Sparingly soluble in H_2O.

139. *How may the amount of iodine in aqueous solution be increased?*

Water which stands in contact with excess of iodine continues to dissolve it. The H_2O is partially decomposed by the I with formation of hydriodic acid (see Q. 140), in a solution of which I is more soluble than in pure H_2O.

The presence of certain salts, as potassium iodide, ammonium chloride, and nitrate, etc., increases the solvent power of H_2O for I. A solution of I in potassium iodide solution is used medicinally under the name of Lugol's solution, or Liq. Iodi Comp. U. S.; Liq. Iodi Br.

140. *Describe the chemical properties of iodine.*

They are very similar to those of Cl and Br, but less active than either, I being driven out of its binary compounds by either Cl or Br. It decomposes H_2O slowly, and sulphuretted hydrogen rapidly, with formation of hydriodic acid and liberation of O or sulphur. Nitric acid oxidizes it to iodic acid.

141. *What substances is commercial iodine liable to be contaminated with?*

Water, coal, graphite, black oxide of manganese, and iodide of cyanogen.

142. *Which is the most important of these, and how may it be separated?*

Iodide of cyanogen, as it is a very poisonous substance. To detect, and at the same time separate it, put at least an ounce of iodine in a porcelain dish, cover this with a large glass flask filled with cold water, and heat the dish upon a water-bath. If iodide of cyanogen be present, white acicular crystals will be observed upon the bottom of the flask, and if the heating be continued for about twenty minutes it will all have collected upon the flask, and and may be thus separated.

143. *How may free iodine or an iodide be detected?*

1. Iodides with silver nitrate solution form a yellow precipitate, insoluble in nitric acid or in ammonium hydrate.

2. Add fuming nitric acid to solution of an iodide, then chloroform and agitate; the chloroform (lower) layer is colored violet.

3. Add palladic chloride to solution of an iodide; a dark-brown precipitate.

4. Free iodine colors starch-paste dark violet-blue.

144. *What compound of hydrogen and iodine is known?*

Hydriodic acid or hydrogen iodide, HI.

145. *What are its properties?*

It is a colorless gas, very soluble in water. Its concentrated aqueous solution has a strong acid reaction, and fumes when exposed to the air. It is decomposed by Cl, Br, oxidizing agents, sulphuric acid, etc, etc. When exposed to the air, the oxygen unites with the hydrogen of the acid, forming water, while the iodine is set free and dissolved in the remaining acid until this becomes saturated with iodine, when the remainder is precipitated in the solid form. It behaves with metals and hydrates like hydrochloric acid.

GROUP II.—SULPHUR GROUP.

SULPHUR	S	32.
SELENIUM	Se	79.5
TELLURIUM	Te	128.

146. *Describe the common properties of the elements of this group.*

They are bivalent. Each forms a hydrogen compound, containing an atom of the element and two atoms of hydrogen, which is a weak dibasic acid. Their oxyacids are all dibasic.

SULPHUR.

147. *What are the symbol and atomic and molecular weights of sulphur ?*

Symbol = S. Atomic weight = 32. Molecular weight = 64.

148. *How does S occur in nature ?*

Free, and in combination in sulphides, sulphates, and organic compounds.

149. *Describe the prominent physical properties of sulphur.*

A yellow, crystalline solid, white when in a finely-divided state, having faint, though characteristic odor and taste. It fuses at 114° (237°.2 F.), and boils at 440° (824° F.). It is insoluble in H_2O, soluble in carbon disulphide, and in protochloride of sulphur.

150. *What is the difference between roll sulphur, flowers of sulphur, and precipitated sulphur?*

Roll sulphur is prepared by pouring melted S into moulds which are cooled. *Flowers* of sulphur are obtained by mixing vapor of S with cold air, when the S assumes the solid form as a great number of small feathery crystals. *Precipitated* sulphur, or *sulphur præcipitatum U. S.*, is obtained by decomposing a sulphide, S being precipitated in a very fine state of subdivision.

151. *What occurs when sulphur is heated in contact with air?*

It burns with a blue flame at about 250°, uniting with the O of the air to form sulphur dioxide—SO_2.

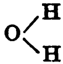
152. *Does sulphur unite directly with any other elements?*

Yes; many metals burn in vapor of S with formation of sulphides; sulphur also burns in an atmosphere of H with formation of hydrogen sulphide.

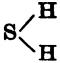
COMPOUNDS OF SULPHUR.

153. *What is an important compound of sulphur and hydrogen, and with what oxygen compound does it correspond?*

Hydrogen sulphide, also known as sulphuretted hydrogen—H_2S. It corresponds with H_2O, only in place of O there is S, and in each one atom of the bivalent O or S is united with two atoms of the univalent H.

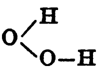


Water.
(Hydrogen oxide.)



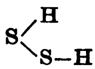
Hydrogen sulphide.

[There is another compound of S and H corresponding to H_2O_2.]



$= H_2O_2$

Hydrogen dioxide.



$= S_2H_2$

Hydrogen disulphide.

154. *How may H_2S be prepared?*

By treating ferrous sulphide with dilute sulphuric acid:

$$\underset{\text{Ferrous sulphide.}}{FeS} + \underset{\text{Sulphuric acid.}}{H_2SO_4} = \underset{\text{Ferrous sulphate.}}{FeSO_4} + \underset{\text{Hydrogen sulphide.}}{H_2S}$$

Also by decomposing antimony trisulphide, or calcium sulphide by HCl.

155. *What are the principal physical properties of hydrogen sulphide?*

It is a colorless gas, having an exceedingly offensive odor of rotten eggs and a correspondingly disgusting taste. Heavier than air (sp. gr. 1.19). Under a pressure of 17 atmospheres it forms a colorless, mobile fluid which crystallizes at −85° (−122° F.). Soluble in water, the solution having an acid reaction, and being decomposed with deposition of S when exposed to the air for some time.

156. *What are the products of combustion of H_2S?*

If the supply of O be small, with formation H_2O and deposition of solid S,

$$\underset{\text{Hydrogen sulphide.}}{2H_2S} + \underset{\text{Oxygen.}}{O_2} = \underset{\text{Water.}}{2H_2O} + \underset{\text{Sulphur.}}{S_2}$$

If, however, the supply of O be sufficient the products are entirely gaseous:

$$\underset{\text{Hydrogen sulphide.}}{2H_2S} + \underset{\text{Oxygen.}}{3O_2} = \underset{\text{Water.}}{2H_2O} + \underset{\text{Sulphur dioxide.}}{2SO_2}$$

Mixtures of air or oxygen with H_2S are explosive.

157. *When H_2S is passed through a solution of a salt what takes place?*

Both the gas and the salt are decomposed with formation of a sulphide and regeneration of the acid:

$$\underset{\text{Cupric sulphate.}}{CuSO_4} + \underset{\text{Hydrogen sulphide.}}{H_2S} = \underset{\text{Cupric sulphide.}}{CuS} + \underset{\text{Sulphuric acid.}}{H_2SO_4}$$

158. *What use is made of this reaction in analysis?*

The sulphides of the different metals, formed as above, vary in their color and in their solubility in acidulated H_2O; therefore, by passing H_2S through a solution we can determine whether certain metals are present or not, according as insoluble colored precipitates are or are not formed. See Manual, p. 369.

159. *How may the presence of H_2S or of a sulphide be detected?*

1. H_2S colors paper moistened with lead acetate solution brown or black.
2. H_2S has the characteristic odor of rotten eggs.
3. A sulphide is decomposed by HCl, yielding H_2S, whose presence is then shown by 1 and 2.

160. *In what gaseous mixtures does H_2S occur?*

In sewer gas, in the emanations from dead bodies, and in the gases discharged from volcanoes.

161. *What should be the treatment in H_2S poisoning?*

Plenty of fresh air, cold affusions, hot brandy and water, inhalation of chlorine largely diluted with air.

162. *What oxides of sulphur are known?*

Sulphur dioxide, SO_2
" trioxide, SO_3

163. *What is another name for sulphur dioxide?*

Sulphurous anhydride; also improperly called sulphurous acid.

164. *What is meant by an anhydride?*

An oxide which will unite with water to form an acid—thus:

$$\underset{\text{Sulphurous anhydride.}}{SO_2} + \underset{\text{Water,}}{H_2O} = \underset{\text{Sulphurous acid.}}{H_2SO_3}$$

165. *Why is the name* sulphurous acid *an improper one for this compound?*

Because it contains no H, which enters into the composition of every acid. The true sulphurous acid is a compound of the anhydride with H_2O.

SO_2	+	H_2O	=	H_2SO_3
Sulphurous anhydride.		Water.		Sulphurous acid.

166. *How may SO_2 be prepared?*

It is formed whenever S is burnt in air, and is also obtained by decomposing sulphuric acid with charcoal or metallic copper:

$2H_2SO_4$	+	C	=	$2SO_2$	+	CO_2	+	$2H_2O$
Sulphuric acid.		Carbon.		Sulphur dioxide.		Carbon dioxide.		Water.

$2H_2SO_4$	+	Cu	=	$CuSO_4$	+	$2H_2O$	+	SO_2
Sulphuric acid.		Copper.		Cupric sulphate.		Water.		Sulphur dioxide.

The copper or coal with the requisite sulphuric acid are placed in a flask which is heated.

167. *Describe the principal physical properties of SO_2.*

A colorless gas, having a suffocating odor (sulphur matches), and a disagreeable and persistent taste. More than twice as heavy as air (sp. gr. 2.317). Liquefies at −10° (+14° F.). It is very soluble in H_2O, which takes up about 40 times its volume at the ordinary temperature.

168. *What is the* Acidum sulphurosum U. S., Br.?

An almost saturated solution of SO_2 in water.

169. *Is this simply a solution of SO_2?*

No; it contains the true H_2SO_3, sulphurous acid, formed by the union of SO_2+H_2O.

170. *What is SO_2 used for?*

As a bleaching and disinfecting agent, and in the manufacture of sulphuric acid.

171. *Explain the bleaching and disinfecting action of SO_2.*

It is a strong deoxidizing agent, uniting readily with O, which it removes from other substances. In the presence of H_2O the true sulphurous acid is formed; this removes the O from more H_2O to form sulphuric acid while H is set free:

$$\underset{\text{Sulphurous acid.}}{H_2SO_3} + \underset{\text{Water.}}{H_2O} = \underset{\text{Sulphuric acid.}}{H_2SO_4} + \underset{\text{Hydrogen.}}{H_2}$$

This H unites with the coloring or odorous principle to form compounds which are colorless or odorless. It also acts as a disinfectant in destroying H_2S.

172. *What action has SO_2 on the economy when inspired?*

In a concentrated form it is poisonous, when diluted with air it produces irritation of the air-passages. Individuals may, however, become by degrees habituated to its presence in air in quantities which would prove fatal to those not so trained.

173. *What substance is represented by the formula SO_3?*

Sulphur trioxide or sulphuric anhydride.

174. *State the properties of SO_3.*

It occurs as long, colorless, transparent prisms, which at 18°.3 (65° F.) melt to an oily liquid, boiling at 46° (114°.8 F.) When exposed to the air it gives off dense white fumes. In the absence of H_2O it has no effect upon litmus paper. It has a great tendency to unite with H_2O to form sulphuric acid, and if dropped into H_2O produces a hissing noise from the violence of the action.

175. *What is the compound having the formula H_2SO_3?*

Sulphurous acid.

176. *Give the formula of sulphuric acid.*

H_2SO_4.

177. *What is the common name of H_2SO_4?*

Oil of vitriol.

178. *What is its basicity, how many sulphates of sodium and of calcium are there, and what are they?*

It is dibasic. There are two sulphates of sodium: monosodic sulphate, $NaHSO_4$, and disodic sulphate, Na_2SO_4; and one sulphate of calcium, calcium sulphate, $CaSO_4$.

179. *Give a general idea of the principle of manufacture of sulphuric acid.*

Sulphurous anhydride is obtained by heating either S or a natural compound of S and iron, called iron pyrites, in a current of air. The anhydride thus obtained is caused to unite with H_2O and O.

$$\underset{\text{Sulphur dioxide.}}{SO_2} + \underset{\text{Water.}}{H_2O} + \underset{\text{Oxygen.}}{O} = \underset{\text{Sulphuric acid.}}{H_2SO_4}$$

The actual reactions are:

First. SO_2 is oxidized by nitric acid with liberation of tetroxide of nitrogen:

$$SO_2 + 2HNO_3 = H_2SO_4 + 2NO_2.$$

Second. The tetroxide of nitrogen so formed combines with H_2O to regenerate nitric acid and form dioxide of nitrogen:

$$3NO_2 + H_2O = 2HNO_3 + NO.$$

Finally, the dioxide so produced is oxidized by air to the tetroxide, which again regenerates nitric acid:

$$2NO + O_2 = 2NO_2.$$

The nitric acid therefore acts as a carrier of O from the air to the SO_2.

The acid so obtained is concentrated by evaporation of the H_2O mixed with it, first in pans of lead, and subsequently in retorts of glass or platinum.

180. *Describe the prominent physical properties of pure H_2SO_4.*

A dense, oily, colorless liquid. Sp. gr. 1.842. Boils at 338° (640° F.), distilling in great part unchanged. Odorless, intensely acid in taste and reaction, and highly corrosive. Non-volatile at ordinary temperatures.

181. *Describe the principal chemical characters of H_2SO_4.*

Heated with S, C, Hg, Cu, or Ag, it is reduced with formation of SO_2. It has a great tendency to unite with H_2O to form definite hydrates, one of which, H_2SO_4,H_2O, crystallizes at 8°.5 (47°.3 F.), and is known as glacial sulphuric acid. When H_2SO_4 and H_2O are mixed, there is marked elevation of temperature. H_2SO_4 absorbs H_2O from the air, and removes its elements from organic substances, which are thereby blackened from liberation of their carbon, *i. e.*, are charred.

182. *Name and describe the varieties of this acid used in the arts and in pharmacy.*

Commercial: An oily fluid, with a brownish tinge (due to charred organic matter); sp. gr. 1.83 to 1.84, and containing 93 to 99½ per cent of true H_2SO_4.

Pure: Acidum sulphuricum, U. S.; Br.: a colorless, oily fluid, having sp. gr. 1.84.

NOTE.—Practically, it is a matter of great difficulty to obtain *perfectly* pure H_2SO_4.

Acidum sulphuricum dilutum, U. S.; Br. is a dilute acid of 1.069 sp. gr. and 9 to 10 per cent H_2SO_4 *U. S.;* sp. gr. 1.094 and 12 to 13 per cent H_2SO_4 *Br.*

183. *What is Nordhausen sulphuric acid?*

A brown liquid obtained by distilling green vitriol ($FeSO_4$), and used in dyeing as a solvent of indigo. It is a mixture of SO_3 with *pyrosulphuric acid* $H_2O_7S_2$, which is itself a compound of $H_2SO_4 + SO_3$.

184. *Describe the tests for soluble sulphates or sulphuric acid.*

1. With barium chloride, nitrate, or acetate, a white precipitate, insoluble in HCl or in nitric acid.

2. With lead acetate, a white precipitate, insoluble in dilute acids.

3. With calcium chloride, a white precipitate, either immediately or on dilution with two volumes of alcohol, insoluble in dilute acids.

Toxicology of H_2SO_4, see Q. 125–129.

185. *How may stains of sulphuric, hydrochloric, and nitric acids on cloth be distinguished from each other?*

When not too old, stains of H_2SO_4 and HCl are bright red, the latter the brighter of the two. They disappear permanently when moistened with aqua ammoniæ. Those of nitric acid are of a yellowish tinge, and are not removed by aqua ammoniæ.

GROUP III.—NITROGEN GROUP.

NITROGEN	N	14
PHOSPHORUS	P	31
ARSENIC	As	75
ANTIMONY	Sb	122

186. *Describe the common properties of the elements of this group.*

They are trivalent or quinquivalent. Each forms a hydrogen compound, containing three atoms of hydrogen combined with one atom of the element. These hydrogen compounds are not acid, but basic in their nature. The oxy-acids differ in basicity from monobasic to tetrabasic.

NITROGEN.

187. *Give the symbol, and atomic and molecular weights of nitrogen.*

Symbol = N. Atomic weight = 14. Molecular weight = 28.

188. *Where does N occur in nature?*

Free in atmospheric air; in combination in the nitrates, in ammoniacal salts, and in organic compounds.

189. *State the more prominent properties of nitrogen.*

It is a colorless, odorless, tasteless gas; lighter than air (sp. gr. 0.972 — air = 1). Very sparingly soluble in water, more soluble in alcohol. Chemically, it is noticeable from its negative characters. It does not burn or support combustion. It does not unite with other elements directly, or does so with great difficulty. Its compounds are nearly all very prone to decomposition. It does not support respiration, but has no positively deleterious action upon the economy.

190. *What are the constituents of atmospheric air?*

Oxygen and nitrogen; with small quantities of carbonic anhydride, vapor of water, ammonia, and nitric acid.

191. *What is the proportion by volume of nitrogen to oxygen in air?*

79 of nitrogen to 21 of oxygen.

192. *Does this proportion vary much in free air?*

No. Although air is a mere mixture, the proportion of its chief constituents remains pretty much the same at different times, seasons, and elevations above the sea level.

193. *What is observed with regard to the solubility of air in water?*

All water, even that which has been recently distilled, contains air in solution, and it is from the air so held in solution that aquatic animals, breathing by means of gills, obtain the oxygen which they require. As air is a mixture, it has not a solubility of its own, but each constituent gas is dissolved according to its solubility, and as oxygen is more soluble in water than nitrogen, the air in solution in water has not the composition 79 nitrogen to 21 oxygen, but 65 nitrogen to 35 oxygen.

See carbonic anhydride, Q. 766 *et seq.*)

194. *What are the name and formula of the compound of nitrogen and hydrogen?*

Ammonia—NH_3.

195. *What are its physical properties?*

It is, under ordinary conditions of temperature and pressure, a colorless gas having a pungent, irritating odor and a caustic taste. It dissolves in H_2O to the extent of 1,050 vols. to one at 0°, and is also very soluble in alcohol.

196. *Describe its chemical characters.*

It does not burn readily, but may be made to do so when mixed with O. It combines with H_2O to form a highly alkaline liquid containing ammonium hydrate, NH_4HO. It combines directly with acids, without separation of hydrogen, to form ammoniacal salts:

$$\underset{\text{Ammonia.}}{NH_3} + \underset{\substack{\text{Hydrochloric}\\ \text{acid.}}}{HCl} = \underset{\substack{\text{Ammonium}\\ \text{chloride.}}}{NH_4Cl.}$$

(See ammonium compounds, Q. 521 *et seq.*)

197. *What compounds of N and O are known?*

Nitrogen	monoxide	N_2O
"	dioxide	NO
"	trioxide	N_2O_3
"	tetroxide	NO_2
"	pentoxide	N_2O_5

198. *By what other names is nitrogen monoxide known?*

Nitrous oxide; laughing gas.

199. *By what method is it prepared?*

By heating ammonium nitrate to a temperature not exceeding 250° (482° F.), when it is split up into N_2O and water—thus:

$$\underset{\text{Ammonium nitrate.}}{(NH_4)NO_3} = \underset{\text{Nitrogen monoxide.}}{N_2O} + \underset{\text{Water.}}{2H_2O}$$

200. *State some of the physical properties of N_2O.*

It is a colorless, odorless gas, having a sweetish taste; heavier than air, sp. gr. 1.527; somewhat soluble in water, more so in alcohol.

201. *How does N_2O rank as a supporter of combustion and respiration?*

After oxygen, it is the best we have; a glowing match-stick rekindles when immersed in the gas, as it does in oxygen; phosphorus and other combustible substances burn in N_2O with almost as much brilliancy as in oxygen, this being due to the fact that at the temperature produced N_2O is decomposed into N and O, and in this mixture the O is in much larger proportion than in air. An animal will also live longer in an atmosphere of N_2O than in any other gas than air or oxygen; but, although the supply of gas be maintained, and the products of respiration be removed, the animal eventually dies of asphyxia.

202. *What effect has N_2O upon the system when inhaled?*

It produces, first, an exhilaration of spirits, frequently accompanied by laughter, and a tendency to muscular exertion, the patient sometimes becoming aggressive; afterwards, loss of consciousness and complete anæsthesia.

203. *What precautions are to be observed in the preparation and use of N_2O as an anæsthetic?*

First, that the gas be pure. The temperature of the retort must not be allowed to rise beyond the point indicated, lest the gas produced be contaminated with the higher oxides of nitrogen. The ammonium nitrate used should be *pure*, and absolutely free from ammonium chloride, or the N_2O will be contaminated with chlorine. In the administration, it must not be forgotten that N_2O alone is not capable of supporting respiration indefinitely; indeed, there is reason to believe that the anæsthesia produced is due to partial asphyxia.

204. *By what other name is nitrogen dioxide known?*

Nitric oxide.

205. *How is NO prepared?*

By the action of copper on nitric acid:

$$\underset{\text{Nitric acid.}}{8HNO_3} + \underset{\text{Copper.}}{3Cu} = \underset{\text{Nitrogen dioxide.}}{2NO} + \underset{\text{Copper nitrate.}}{3Cu(NO_3)_2} + \underset{\text{Water.}}{4H_2O}$$

206. *What are its physical properties?*

A colorless gas, sparingly soluble in water. Its taste and odor are unknown.

207. *What takes place when NO comes in contact with air or oxygen?*

Under these conditions, NO immediately unites with O to form NO_2.

208. *What is another name for nitrogen trioxide?*

Nitrous anhydride; improperly, nitrous acid.

209. *Under what name is nitrogen tetroxide sometimes improperly designated?*

Hyponitric acid.

210. *State its properties.*

It is a brown gas, having a disagreeable, suffocating odor; it is very irritating to the respiratory passages, colors the skin yellow, and is an energetic oxidizing agent.

211. *How is it formed?*

Whenever a metal, as copper, silver, or mercury, is dissolved in nitric acid, the acid is decomposed, as in Q. 582; the NO formed, as soon as it comes in contact with air, absorbs O and is converted into NO_2. As this gas is very deleterious, care should be had that it have a free exit into the open air whenever nitric acid is decomposed, as in the formation of metallic nitrates.

212. *What is another name or nitrogen pentoxide?*

Nitric anhydride.

213. *How many nitrogen acids are there, and what are they?*

Three:

Hyponitrous acid—HNO.
Nitrous acid—HNO_2.
Nitric acid—HNO_3.

214. *Give the formula and basicity of nitric acid.*

HNO_3. Monobasic.

215. *What is a common name for nitric acid?*
Aqua fortis.

216. *How does it exist in nature?*
It exists in combination with the metals as nitrates. Those of potassium and sodium are the most abundant and are the chief sources of nitric acid. Ammonium nitrate occurs in small quantities in atmospheric air, especially after thunder showers.

217. *What is the principle of the manufacture of HNO_3?*
Sulphuric acid is caused to act upon potassium or sodium nitrate, when:

$$\underset{\text{Potassium nitrate.}}{KNO_3} + \underset{\text{Sulphuric acid.}}{H_2SO_4} = \underset{\text{Monopotassic sulphate.}}{KHSO_4} + \underset{\text{Nitric acid.}}{HNO_3}$$

218. *What are the physical properties of pure nitric acid?*
A colorless liquid, having a penetrating odor and an intensely sour taste. When cooled to − 40° (− 40° F.) it forms a solid. It boils at 86° (186°.8 F.).

219. *State some of the chemical properties of HNO_3.*
It has a strongly acid reaction, turning blue litmus red and neutralizing alkalies. It acts energetically upon all animal tissues, decomposing them and turning such as contain albuminoid substances yellow. It gives up part of its oxygen with great readiness and is, therefore, a powerful oxidizing agent. It is readily decomposed by most metals with formation of

nitrates. When exposed to air and light, it becomes yellow and is decomposed into NO_2, H_2O, and O.

220. *Name and describe the varieties of* HNO_3 *met with in commerce and pharmacy.*

Commercial: A yellow liquid, contaminated with the oxides of nitrogen, HCl, arsenic, and other impurities. It is met with in two degrees of strength: *Single aqua fortis* = 39 per cent HNO_3; and *double aqua fortis* = 64 per cent HNO_3.

Fuming: A concentrated acid containing much nitrogen tetroxide, which gives it a deep yellow color. It is a powerful oxidizing agent.

Chemically pure (C. P.) acid: Perfectly colorless; sp. gr. 1.521. Should be kept in bottles completely full, and protected from the action of light.

Acidum nitricum, U. S.; Br., a colorless acid, of sp. gr. 1.42 = 70 per cent HNO_3.

Acidum nitricum dilutum, U. S.; Br., the last-named diluted; sp. gr. 1.059 = 10 per cent HNO_3, *U. S.;* sp. gr. 1.101 = 17.44 per cent, *Br.*

221. *Describe the tests for nitrates or* HNO_3.

1. Add an equal volume of H_2SO_4, cool, and float on the surface of the liquid a solution of ferrous sulphate; the lower layer becomes gradually brown, black, or purple, beginning at the top.

2. Boil in a test tube some HCl containing enough indigo-carmine to color it blue, add the liquid to be tested, and boil again; the color is discharged.

3. If acid neutralize with potassium hydrate. evaporate to dryness, moisten with H_2SO_4, and add a crystal of brucine: a red color.

4. Add H_2SO_4 and fragments of copper; boil; brown fumes.

222. *What is the appearance of stains upon the skin or mucous membrane caused by HNO_3?*

Not red as with HCl or H_2SO_4, but at first yellow, changing to dirty brownish-yellow.

(Toxicology, see Q. 123–129.)

PHOSPHORUS.

223. *Give the symbol, and atomic and molecular weights of phosphorus.*

Symbol = P. Atomic weight = 31. Molecular weight = 124.

224. *Of how many atoms does the molecule of phosphorus consist?*

Of four.

225. *How does phosphorus exist in nature?*

It is not found in its own form, but is widely distributed in combination in the three kingdoms of nature. In the animal, it occurs both oxidized in the form of phosphates (the phosphorus used in the arts is obtained exclusively from calcic phosphate existing in bones), as well as in certain organic compounds entering into the composition of the nerve tissue.

226. *What is meant by allotropy?*

Some elements, as phosphorus and carbon, exist in two or more different conditions, in which, although the chemical relations remain unaltered, the physical properties vary more or less widely; these different conditions of the same element are said to be allotropic.

227. *In how many allotropic conditions does phosphorus exist, and what are they?*

Four—black, white, red, and yellow. Of these, the last two are the most frequently met with.

228. *What are the physical properties of the ordinary, or yellow, variety?*

When freshly prepared, and at ordinary temperatures, it forms a yellowish, translucent solid, which, on exposure to light, becomes more darkly colored and opaque; it has the consistency of wax; when exposed to the air, it gives off white fumes and an odor of garlic. At 0° (32° F.) it becomes brittle; at 44° (111° F.) it melts to a yellowish fluid, and at 290° (554° F.), in the absence of air, is converted into a colorless vapor. In air, at 60° (140° F.), it ignites, burning with a bright flame, and giving off dense, white fumes. Owing to the readiness with which P ignites, and the painful nature of the burns produced by it, it should never be cut, except under H_2O, and should not be handled, except with forceps. In the dark, this form of P gives off a peculiar pale light. It is insoluble in H_2O; sparingly soluble in alcohol, ether, and the fatty and ethereal oils; very soluble in bisulphide of carbon, from which solution it separates in the form of crystals.

229. *What are the physical properties of the red variety?*

It is red, brown, or dark yellow in color. It may be heated to 250° (482° F.) without melting, but at that temperature it is suddenly converted into the yellow variety, which ignites with an explosion. It fires much less readily than yellow phosphorus, and may be kept dry, while the yellow must be preserved under H_2O. It has no odor or taste, and is insoluble in those substances which dissolve the other form.

230. *What is the most important difference between the two forms?*

The yellow variety is exceedingly poisonous, while the red is entirely innocuous.

231. *How may yellow phosphorus be pulverized?*

By melting it under H_2O, and agitating the mixture until it has cooled so far that the phosphorus has solidified in a finely divided form.

232. *How is red P prepared?*

By maintaining the yellow variety at from 240° (464° F.) to 280° (536° F.) in an atmosphere of carbon dioxide for two to three days, and, after cooling, washing out the unaltered yellow P with carbon disulphide.

233. *What are the chemical characters of phosphorus?*

It combines readily with oxygen, the yellow modification at lower temperatures than the red, to form an oxide if the oxygen be dry, an acid in the presence of moisture. It combines directly with Cl, Br, and I. It is not acted on by HCl or by cold H_2SO_4. It is rapidly oxidized by HNO_3. It is an energetic reducing agent.

234. *How many varieties of phosphorus poisoning may occur, and what are they?*

Two. 1st. The acute form consequent upon the ingestion of a poisonous dose of the element; and 2d. The chronic form (also known as the Lucifer disease), affecting those engaged in certain branches of match manufacture.

235. *How does the acute form occur?*

The recorded cases are about equally divided between accidental, suicidal, and murderous. The substances used being either match heads (which are composed, in the common sulphur match, of potassium chlorate, fine sand, phosphorus, and a coloring matter), or rat poison, which is a mixture of phosphorus with flour.

236. *What circumstances affect the rapidity with which symptoms appear in these cases?*

The action is much accelerated by the presence of any oily or fatty matter, which dissolves the poison, and thus favors its absorption. The symptoms usually make their appearance within two or four hours after ingestion of the poison, but they may be delayed for days.

237. *Describe the prominent symptoms in acute phosphorus poisoning.*

Eructation of gas having the taste of P. The mouth, when observed in the dark, is frequently faintly luminous (phosphorescent). After several hours, pain in the throat, a sense of heat in the epigastrium, nausea, and vomiting. The vomited matters are sometimes bloody, and frequently (see Q. 242) luminous when agitated in the dark. The abdomen is tender, and there are diarrhœa and colicky pains. After one or two days, these symptoms cease, there remaining only pain in the back and limbs and a feeble pulse. Death sometimes occurs suddenly in from two to four days. Usually about the fourth day the patient becomes jaundiced, suffers from headache, insomnia, and retention of urine, rapidly becomes delirious and comatose, and dies.

238. *What is the lethal dose of phosphorus?*

The smallest quantity of P that has been known to cause the death of an adult was 0.008 gram (⅛ grain).

239. *What treatment is to be followed?*

We have no chemical antidote; therefore, all efforts are to be directed to getting the poison out of the system as rapidly as possible. For this purpose the stomach-pump or an emetic of zinc sulphate are indicated. If the poison have had time to reach the intestine, a cathartic should also be administered. *Give no oily or fatty matter, or any substance containing them.* Oil of turpentine has been used with advantage as a physiological antidote. The older the oil the better its action seems to be.

240. *What post-mortem appearances are observed after death by acute phosphorus poisoning?*

Occasionally small fragments of P may be detected by their luminous appearance in the stomach or intestines. The œsophagus, stomach, and intestines are frequently marked with ecchymotic spots. Advanced fatty degeneration is observed in the liver, kidneys, heart, and muscular tissue. The blood is very fluid, and the red corpuscles more transparent than normal.

241. *Describe Mitscherlich's process for detecting phosphorus.*

This process is based upon the property of unoxidized phosphorus of becoming luminous in the dark. The matters supposed to contain the poison are rendered fluid by dilution with water and acidulated with sulphuric acid. They are placed in a flask upon a sand bath, and the flask connected with a Liebig's condenser, which is placed in absolute darkness. Upon heating the flask, any phosphorus present is volatilized, and condensing in the tube forms a luminous ring. This reaction is very delicate, and the appearance of the ring is proof positive of the presence of unoxidized phosphorus.

242. *Under what conditions will this process fail?*

The presence of certain volatile substances destroys the luminosity of phosphorus; prominent among these are alcohol, ether, and oil of turpentine. In the case of the former two, which are quite volatile, the luminous ring does not appear until they have distilled over, and are thus separated. When oil of turpentine is present, the luminous property of phosphorus is permanently destroyed; consequently, when it is known that this substance has been administered, this process should not be resorted to, and in any case only half the material should be used.

See Manual, pp. 80, 81.

243. *Give a short description of the process of match manufacture.*

The wooden splints are dipped for about a third of their length in some combustible substance, as melted sulphur or paraffin; after this has set, they are pointed with the phosphorus paste. This paste is spread out on an iron plate, which is warmed. During the process (when the mixture does not fire, which frequently occurs) fumes of the lower oxides of phosphorus are given off. After the pointing process, the matches are arranged in the drying-room, from which they are taken to be packed.

244. *What classes of operatives are liable to the lucifer disease?*

Those who are engaged in the manufacture of phosphorus are not attacked by it, but those who are engaged in the pointing, drying, and packing of matches. Weak and scrofulous females are more subject than others.

245. *How may this form of poisoning be diminished in frequency, and prevented?*

Many methods have been resorted to for this purpose. 1st. Strict cleanliness and good ventilation of the shop are imperative. 2d. The mouth is frequently washed with a weak solution of sodic carbonate. 3d. Saucers filled with turpentine are placed in the rooms. There is only one method, however, of completely remedying the evil, which is the absolute prohibition of the use of yellow phosphorus in the manufacture of matches. The increased cost of red phosphorus is more than counterbalanced by the advantages of preventing this fearful disease, and at the same time removing from the reach of the poisoner one of the most potent and easily obtained of toxic agents.

246. *What is the composition of gaseous phosphoretted hydrogen?*

PH_3.

247. *How may it be prepared?*

By the action of concentrated solution of caustic potash upon phosphorus, or by the decomposition of a compound of phosphorus and calcium by water.

248. *What are the properties of the gas as thus obtained?*

It is colorless and has a disgusting odor of rotten fish; almost insoluble in water, easily soluble in alcohol or ether. As each bubble of the gas comes in contact with the air it inflames and produces a ring of smoke. It is highly poisonous.

249. *What other substance is present in the gas as thus obtained, and what property is due to its presence?*

It is contaminated with small quantities of another compound of phosphorus and hydrogen, which is liquid at ordinary temperatures and has the composition of P_4H_2; it is to the presence of this substance that it owes the property of igniting on contact of air. The pure gas only ignites when heated to 100° (212° F.).

250. *How many compounds of phosphorus and chlorine are known, and what are they?*

Two. Phosphorus trichloride, $P'''Cl_3$,
Phosphorus pentachloride, P^vCl_5.

PCl_3 is a colorless liquid formed by the direct union of chlorine and phosphorus. When the chlorine is in excess, the solid PCl_5 is formed.

251. *What compounds of phosphorus and oxygen are known?*

Two. Phosphorus trioxide, P_2O_3,
Phosphorus pentoxide, P_2O_5.

252. *Under what other name is P_2O_3 known, how is it formed, and what are its properties?*

Phosphorous anhydride. It is formed when phosphorus is oxidized in a very limited quantity of perfectly dry air or oxygen. As soon as it is exposed to air containing a small quantity of moisture it ignites from the heat produced by its union with H_2O to form phosphorous acid.

253. *What is another name for P_2O_5, and how is it formed?*

Phosphoric anhydride. It is formed when phosphorus is burned in dry air or oxygen.

254. *What are its properties?*

It is a snowy white, flocculent powder, having a tendency to unite with water, which it absorbs from other substances greedily (owing to this property it forms a valuable drying agent), forming a highly acid liquid.

255. *Give the names and formulæ of the acids containing phosphorus.*

Hypophosphorous acid, H_3PO_2; Phosphorous acid, H_3PO_3; Orthophosphoric acid, H_3PO_4; Pyrophosphoric acid, $H_4P_2O_7$; Metaphosphoric acid, HPO_3.

256. *What are the basicities of these acids?*

Hypophosphorous acid is monobasic; phosphorous acid, dibasic; orthophosphoric, tribasic; pyrophosporic, tetrabasic; and metaphosphoric, monobasic.

257. *Write the formulæ of the sodium (univalent) salts of the phosphorus acids.*

NaH_2PO_2; NaH_2PO_3; Na_2HPO_3; NaH_2PO_4; Na_2HPO_4; Na_3PO_4; $NaH_3P_2O_7$; $Na_2H_2P_2O_7$; $Na_3HP_2O_7$; $Na_4P_2O_7$; $NaPO_3$.

258. *How does orthophosphoric acid occur in nature?*

It is not found free, but is very widely disseminated in combination in the phosphates, in the mineral, vegetable, and animal world.

259. *By what other names is it known?*

Common phosphoric acid or tribasic phosphoric acid.

260. *How is it prepared?*

By the direct oxidation of P by means of HNO_3. The reaction, which is dangerous when yellow P is used, is started by the application of heat and, once started, continues without further heating.

261. *What is the acidum phosphoricum dilutum, U. S.; Br.?*

A solution of orthophosphoric acid prepared as above, and diluted with water to sp. gr.; 1.056 and containing 10 per cent of acid, U. S.; sp. gr. 1.08 = 14 per cent of acid, Br.

262. *By what tests may orthophosphoric acid or an orthophosphate in solution be detected?*

1. Add some solution of ammonium chloride containing free ammonia, and then solution of sulphate of magnesium; if H_3PO_4 be present, a white crystalline precipitate is formed.

[The same reaction occurs if an arsenate be present.]

2. To the neutral solution add solution of nitrate of silver; if H_3PO_4 be present, a yellowish-white precipitate is formed, which dissolves on addition of HNO_3 or of ammonium hydrate. [If the precipitate were formed by an arsenate, it would not be yellowish, but brown or brick red.]

3. To dilute HNO_3, add the solution to be tested, and then solution of ammonium molybdate; if H_3PO_4 be present, a yellowish precipitate is formed.

ARSENIC.

263. *Give the symbol and atomic and molecular weights of arsenic.*

Symbol = As. Atomic weight = 75. Molecular weight = 300.

264. *Of how many atoms is the molecule of arsenic composed?*

Of four.

265. *How does arsenic exist in nature?*

In small quantities in the elementary form; more abundantly in three sulphur compounds; realgar, orpiment, and mispickel, the last being a compound of sulphur, arsenic, and iron.

and the chief ore of arsenic. It also exists in small quantities in many ores and in traces in the waters of certain mineral springs.

266. *What are the properties of arsenic?*

It is a steel gray solid, having a metallic lustre. When pure, it is odorless and tasteless; easily powdered; sp. gr. 5.6 to 5.9; when heated to 180° (356° F.) without access of air, it distils unchanged and without melting. It is a good conductor of electricity.

267. *What action have air and water upon As?*

At ordinary temperatures it remains unchanged in *dry* air; at high temperatures it unites rapidly with O, producing a strong bluish-white light. When pure, it is insoluble in H_2O. but when exposed to that fluid or to damp air, it becomes tarnished from the formation of a film of oxide upon its surface. and this oxide is dissolved to a certain extent by the H_2O.

268. *For what purposes is arsenic used in the arts?*

It is mixed with lead in the manufacture of shot; it enters into the composition of fly poison. and is used in certain fireworks.

269. *What compound of arsenic and hydrogen is known?*

Arseniuretted hydrogen or hydrogen arsenide, AsH_3.

270. *Under what conditions is this substance formed?*

When nascent hydrogen is in presence of an arsenical compound.

271. *What are its physical properties?*

A colorless gas having a strong odor of garlic, soluble in five volumes of air-free H_2O; burns in air.

272. *How is it affected by red heat in the absence of air?*

It is decomposed into its constituent elements, As being deposited as a brilliant metallic solid, and H passing off as gas.

273. *What is produced when AsH_3 is burnt in air?*

If the flame be not interfered with, the combustion is complete, the H forming H_2O and the As, As_2O_3. The latter may be condensed on a cold surface held above the flame, in the form of white octahedral crystals.

If the flame be cooled by introduction into it of a cold surface, the oxidation is limited to the formation of H_2O, and elementary As is deposited upon the cold surface as a brown or dark gray film.

274. *What changes are caused by passing AsH_3 through a solution of silver nitrate?*

The solution is darkened, and deposits a black sediment of metallic silver. Arsenious acid is produced, and remains in the solution.

275. *Name the compounds of arsenic and oxygen.*

Arsenic trioxide, As_2O_3.
Arsenic pentoxide, As_2O_5.

276. *Under what other names is arsenic trioxide known?*

Arsenious anhydride; white arsenic, and, improperly, as arsenious acid; acidum arseniosum, U. S.; Br.

277. *What are the physical properties of* As_2O_3*?*

It occurs in two allotropic conditions. When freshly prepared, it forms small, transparent, shining, eight-sided crystals, which, on exposure to air, become opaque, forming the heavy white powder known as white arsenic. If this substance be kept near its point of volatilization it melts, and, on cooling, forms the second variety, which is a transparant, glassy, structureless mass, having a faint yellowish tinge; this variety is gradually converted into an opaque, white, porcelainous substance upon the surface, by exposure to air, but if the mass be broken, its interior will be found still glassy. These two varieties are both odorless and have a faint taste, somewhat acrid and metallic at first, afterwards sweetish; they differ from each other in their solubility in water, etc.

The sp. gr. of the vitreous variety in 3.785, that of the crystalline, 3.689.

278. *Describe and explain what is observed when powdered white arsenic is thrown on water.*

Notwithstanding its high sp. gr., a portion only sinks, the remainder floating on the surface. The particles of the portion which sinks are no longer distinct, but are collected in lumps, each of which incloses a bubble of air. The floating particles also have air-bubbles adherent to them. A film of air therefore adheres to the surface of the arsenic, and prevents its contact with the water.

279. *What is the solubility of white arsenic in pure water?*

The vitreous variety is more readily and more rapidly soluble than the crystalline, but by prolonged boiling the solubilities of the two become more nearly equal. Even after long contact with a large excess of cold H_2O all of the crystalline arsenic is not dissolved. One thousand parts of cold H_2O in contact with powdered white arsenic for twenty-four hours dissolves about two parts of the oxide. The same amount of boiling H_2O put upon the powder and allowed to stand twenty-four hours dissolves about 10 parts, and the same amount of H_2O boiled on the powder for one hour, the amount of liquid being kept the same, dissolves about 65 parts. A hot saturated solution may be evaporated to half its bulk without depositing any of the oxide, and, if allowed to cool, it still retains a large amount. A solution at 16° (60°.8 F.) may thus be obtained containing 50 part in 1,000.

280. *How is the solubility of white arsenic in water influenced by the presence of other substances?*

The presence of mineral acids, or alkalies, ammonia, ammoniacal salts, alkaline carbonates, tartaric acid, or tartrates increases the solubility. Fats and other organic substances (the various liquid articles of food) diminish the solubility.

NOTE.—In medico-legal cases it must not be forgotten that a poisonous substance may be swallowed with a drink without being in solution. If the beverage be mucilaginous, or be stirred immediately before drinking, the amount held in suspension may greatly exceed that held in solution.

281. *If As_2O_3 be heated in a tube, what occurs?*

It volatilizes unchanged, and is deposited in the cool parts of the tube in the form of small, brilliant, white, eight-sided crystals.

282. *If heated in the presence of charcoal, what occurs?*

It gives up its oxygen readily; carbonic anhydride is formed, while arsenic is deposited in the elementary form.

283. *How does As_2O_3 behave with oxidizing agents?*

It takes up oxygen readily; in aqueous solution, exposed to the air, a portion is converted into H_3AsO_4; with HNO_3, the action is more rapid, H_3AsO_4 being formed, while brown fumes are given off.

284. *What action has hydrogen sulphide on As_2O_3 in acid solution?*

Both substances are decomposed, the tersulphide of arsenic, As_2S_3, being deposited as an insoluble yellow powder.

285. *For what purposes is As_2O_3 used in the arts?*

In the manufacture of green pigments; of opaque white glass; in calico printing; in the preservation of animal substances by the taxidermist and in dissecting; as a vermin poison, and as the starting-point in the manufacture of arsenical compounds.

286. *What is the true arsenious acid?*

This substance has not been isolated, but is considered as existing in solutions of arsenious anhydride, and having the formula H_3AsO_3 (corresponding to that of phosphorous acid); there are, however, a number of important salts corresponding to this acid, known as arsenites.

287. *What is produced when a solution of sodium carbonate is heated with white arsenic?*

A solution of sodium arsenite. Carbon dioxide is given off:

$$\underset{\substack{\text{Sodium}\\\text{carbonate.}}}{2Na_2CO_3} + \underset{\substack{\text{Arsenic}\\\text{trioxide.}}}{As_2O_3} + \underset{\text{Water.}}{H_2O} =$$

$$= \underset{\substack{\text{Disodic}\\\text{arsenite.}}}{2Na_2HAsO_3} + \underset{\substack{\text{Carbon}\\\text{dioxide.}}}{2CO_2}$$

288. *What is Fowler's solution?*

A solution of potassium arsenite in water, containing comp. tinct. lavender to give it taste and odor, that it may not be mistaken for water.

289. *What is Scheele's green?*

Arsenite of copper.

290. *What is Schweinfurt green?*

A compound of arsenite and acetate of copper; aceto-metarsenite of copper.

291. *Under what name is Schweinfurt green known in the U. S.?*

Paris Green.

292. *What is another name for arsenic pentoxide, and what are its properties?*

Arsenic anhydride. It is a heavy, white solid, gradually but abundantly soluble in water.

293. *What is produced when* As_2O_5 *is dissolved in* H_2O*?*

An acid solution of arsenic acid, H_3AsO_4.

294. *What phosphorus acid does arsenic acid resemble in its chemical properties?*

Orthophosphoric acid. It is converted into pyroarsenic and metarsenic acids under the same conditions under which phosphoric acid yields pyrophosphoric and metaphosphoric acids. Its salts, called arsenates, resemble in constitution the corresponding compounds of phosphoric acid.

295. *What is realgar, and how does it occur?*

Arsenic disulphide, As_2S_2. It is found in nature in translucent red crystals, and is also manufactured commercially by melting together arsenic trioxide and sulphur; as thus prepared, it forms dark-red amorphous masses, tasteless and odorless. In powder it is orange-yellow, insoluble in water, alcohol, or dilute hydrochloric acid.

296. *How do the natural and artificial realgars differ in their action when taken internally, and why?*

The native realgar is inert, while the artificial product is poisonous. The sulphide is in both cases non-poisonous, but the artificial realgar always contains arsenic trioxide.

297. *Under what other name was realgar formerly known?*

In some older works it is known as *sanda-*

rach, which name has since been applied to a resin used in making incense, and to a slight extent in medicine.

298. *What is the common name for arsenic trisulphide, and how does it occur?*

Orpiment. It is found in nature as brilliant, yellow, gold-like scales and crystals. It is also manufactured artificially by subliming together arsenic trioxide and sulphur; this product, like artificial realgar, always contains arsenic trioxide which renders it poisonous. Pure As_2S_3 may be obtained by passing sulphuretted hydrogen through an acid solution of arsenic trioxide, and washing the deposit.

299. *What relation has As_2S_3 to As_2O_3, chemically?*

As As_2O_3 is the anhydride of arsenious acid, so As_2S_3 is the anhydride of an acid of similar composition, in which the oxygen is replaced by sulphur, called sulpharsenious acid, AsS_3H_3, and corresponding to which are salts called sulpharsenites.

300. *How is As_2S_3 used in the arts?*

As a pigment under the name *King's yellow;* mixed with lime and water, to form a paste called *rusma*, used in dressing hides, and as a depilatory.

301. *What other compound of sulphur and arsenic is known?*

Arsenic pentasulphide, As_2S_5.

302. *What is Donovan's solution?*

A solution of mercuric iodide and and arsenious iodide, AsI_3.

303. *Name some of the compounds of arsenic which have given rise to poisoning.*

Elementary arsenic, hydrogen arsenide, arsenic trioxide, potassium or sodium arsenite, artificial sulphides of arsenic, arsenical greens.

304. *In what way may elementary arsenic cause poisoning?*

By the ingestion of fly paper or the H_2O in which it has been moistened. The As with which the paper is charged is converted into H_3AsO_3 by the action of air and moisture.

305. *How has AsH_3 caused poisoning?*

By inhalation of H made from Zn and H_2SO_4 containing As.

306. *Which of the arsenical compounds has been the most frequently administered with homicidal intent?*

Arsenic trioxide.

307. *By what channels has it been so administered?*

By the mouth, by injection into the rectum and into the male urethra, by the vagina.

308. *Have fatal cases of arsenical poisoning resulted from the external application of arsenical compounds?*

Yes, numerous cases are recorded resulting from the rubbing of arsenical preparations into the scalp, scrotum, etc., to kill parasites, as well as by the use of such preparations by quacks as cancer cures.

309. *What is the lethal dose of white arsenic?*

The smallest amount known to have caused the death of an adult was 0.162 gram (2½ grains). A case is recorded in which 62 grams (℥ ij.) were taken without causing death.

310. *State the conditions which favor the activity of the true poisons.*

1. When taken in solution or in a form readily dissolved by the gastric secretions. 2. When vomiting does not occur or is delayed. 3. When taken into the empty stomach with little or no solid food. 4. When the person exercises actively after the poison has been taken. 5. When taken into a system already weakened by disease.

311. *State the conditions which impede the action of the true poisons.*

1. When taken in a form insoluble either by reason of chemical combination or physical condition. 2. When vomiting is copious and occurs early. Almost the entire quantity taken may be thus expelled before absorption has occurred to any great extent. 3. Sleep. 4. When taken by a person already under the influence of a drug having antagonistic action. 5. When taken by one habituated to its use.

312. *In what way may the arsenical pigments give rise to accidental poisoning?*

By inhabiting rooms the walls of which are covered with paper colored by these substances; by the use of articles of clothing or ornament dyed with them; by sucking ornamental confectionery of a green color; and by the accidental mixing of Paris green, used to exterminate vermin, with articles of food.

313. *What are the prominent symptoms of acute arsenical poisoning?*

They usually begin in from 20 to 45 minutes. Nausea and faintness. Violent, burning pain in the stomach, which becomes more and more intense and increases on pressure. Persistent and distressing vomiting of matters, sometimes brown or gray, or streaked with blood, or green (Paris green), or black or blue (charcoal or indigo powder mixed with As_2O_3 according to the English law). Purging; more or less severe cramps in the lower extremities.

314. *What are the prominent symptoms of chronic arsenical poisoning?*

Inflammation of the conjunctivæ with intolerance of light. Irritation of the skin, accompanied by an eruption (eczema arsenicale). Local paralyses. Great weakness and emaciation. Exfoliation of the cuticle and falling out of the hair.

315. *What should the treatment be in acute arsenical poisoning?*

If vomiting have not occurred, it should be induced by tickling the fauces or by zinc sulphate, never by tartar emetic; the stomach pump should be used if the case be seen very early. Moist, recently prepared ferric hydrate, or "dialyzed iron," should be administered.

316. *How is ferric hydrate prepared for this purpose?*

Add to solution of ferric sulphate (liq. ferri tersulphatis, U. S.; liq. ferri persulphatis, Br.) excess of aqua ammoniæ, collect upon muslin and wash with water. It should be prepared when wanted and administered while still moist, in doses twenty times as great as the amount of arsenic presumed to have been taken.

317. *What test should be applied to the urine during life to detect the presence of arsenic?*

Reinsch's test (see Q. 328–331).

318. *When should this test not be used and why?*

It should not be applied to any portion of the body after death in a case of suspected homicide, until the presence of arsenic has been demonstrated by other tests, and until after the relative amounts of As and Cu have been determined. If this precaution be neglected, Cu is introduced into the substances under examination and the distinction between As_2O_3 and Paris green becomes impossible.

319. *Describe the post-mortem appearances in acute arsenical poisoning.*

They are confined to the stomach and intestines. The stomach is inflamed, whether As has been taken by the mouth or by other channels of absorption. The mucous surface is coated with a layer of mucus, tinged with blood or bile, and sometimes containing white crystals of As_2O_3 or green particles of Paris green. The color of the mucous membrane is brownish red, interspersed with darker streaks or patches between the rugæ. The small intestines are sometimes inflamed throughout their length, but more usually the inflammation is limited to the duodenum.

320. *Is the above appearance of the stomach positive proof that the poison was taken during life?*

It is not. When As_2O_3 is injected into the stomach after death, the walls of the viscus become reddened so as closely to simulate the appearance of inflammation.

321. *What portions of the cadaver should be preserved for analysis in cases of suspected homicide?*

The alimentary canal from the cardia to the middle of the rectum *unopened*, and the contents inclosed by ligatures at the œsophagus, duodenum, and lower end of gut. One third of the liver, including the gall bladder; one kidney; the spleen; a piece of muscular tissue; the brain, and any urine which may remain in the bladder.

Any suspected food articles, and any obtainable vomited matter are to be also preserved.

322. *How should these parts be preserved?*

They are to be placed in *clean* and *new* glass jars, closed with glass or cork covers or stoppers. Jars with metallic caps should never be used. Tapes or cords should be tied about the jar and cap, to which they should be attached by sealing wax bearing impressions of a seal, in such a manner that access can only be had to the interior after breaking the seals or cutting the tapes or cords. Great care must be exercised that no sealing wax can get into the jars. Each portion should be placed in a jar by itself.

323. *What should be particularly noted in examining the cadaver superficially?*

The presence or absence of incisions of the course of the arteries, particularly femorals and carotids, as indicating whether or no the body has been embalmed.

324. *How may solutions of arsenious and arsenic acids be distinguished from each other?*

By solution of nitrate of silver in presence of ammonia; with solution of arsenious acid silver arsenite is formed as a *yellow* precipitate, while with solution of arsenic acid silver arsenate is formed as a *chocolate-brown* precipitate.

325. *Upon what reactions is Marsh's test for arsenic based.*

1. When nascent H is formed in presence of an arsenical compound AsH_3 is produced.

2. When AsH_3 is passed through a red hot tube it is decomposed into As and H.

3. When AsH_3 is burned and a cold surface held *above* the flame, As_2O_3 is deposited in octahedral crystals.

4. When AsH_3 is burned and a cold surface held *in* the flame As is deposited as a brown or black stain.

5. When AsH_3 is passed into a solution of silver nitrate, metallic Ag is deposited and the solution contains H_3AsO_3.

6. When As is heated in a current of air, it disappears and octahedral crystals of As_2O_3 are formed.

(See Manual p. 93.)

326. *What substance may be mistaken for arsenic by this test?*

Antimony, which under the same conditions produces stains and mirrors closely resembling those of arsenic.

327. *How may the two substances be distinguished?*

By gently heating the deposit in one of the tubes, when it disappears rapidly and octahedral crystals are formed if it be As.

It requires a higher degree of heat to cause the disappearance of the antimonial deposit, and the white sublimate into which it is converted is not crystalline.

(See Manual p. 95.)

328. *Describe Reinsch's test for arsenic.*

Add to the suspected fluid one-sixth its volume of pure hydrochloric acid; suspend in the fluid a piece of bright electrotype copper and boil. If a steel gray deposit forms on the copper, remove the copper with its adhering deposit, wash it with pure water, and dry between folds of filter paper, being careful not to rub off the deposit. Coil up the copper and put it into a clean, dry tube, open at both ends, holding the tube at such an angle that the spiral does not slip out; apply heat at the part containing the copper.

329. *What other substances produce deposits similar to those of arsenic, and how may they be distinguished?*

Antimony, mercury, bismuth, gold and platinum. If either of these be present, a gray or black deposit is formed on the copper. If the deposit be arsenic, there will form in the cold part of the tube during heating of the part containing the copper, a white deposit composed of small octahedral crystals of arsenic trioxide; if antimony, a white sublimate will form, but it will have no crystalline appearance; if bismuth, platinum, or gold, no sublimate will be formed; and if mercury, there will form a deposit of metallic mercury in small, brilliant globules.

330. *What precautions are to be observed in this test?*

Be sure of the purity of the copper and hydrochloric acid used; boil a strip of the copper in the acid diluted with five volumes of distilled water for at least half an hour to test them. Use only a small piece of copper at the beginning; when a deposit has formed on that, remove it and substitute another, and so on until all the arsenic present has been collected. Do not conclude that arsenic is absent until the boiling has continued half an hour.

331. *When is Reinsch's test not applicable?*

When arsenic is present in the form of arsenic acid or an arsenate; in this case the deposit is not formed at all, or only with great difficulty. When it is suspected that the substance present is an arsenate, it should be reduced to an arsenite by sulphurous acid before applying Reinsch's test. The test cannot be applied in the presence of oxidizing agents, such as free nitric acid, potassium chlorate, nitrates in large quantity, etc. On the other hand, this test is the only one that can be applied to fluids containing organic matter.

332. *What reaction takes place when H_2S is passed through alkaline and acid solutions of arsenious acid or the arsenites?*

If the solution be alkaline it becomes yellow, if acid a precipitate of yellow arsenic trisulphide is formed.

333. *What reaction occurs when a solution of an arsenate is treated with H_2S?*

The arsenate is first reduced to arsenite with deposition of sulphur, subsequently the yellow precipitate of As_2S_3 is slowly formed. The complete separation of the As in this case requires several days.

334. *Describe the* reduction test *for arsenic.*

Place the solid to be examined in the closed end of a small tube and above it a fragment of charcoal; heat the charcoal to redness and then heat the solid under it. In the presence of As a brilliant metallic "mirror" is formed in the tube. The materials and tube must be perfectly dry.

335. *Describe the sublimation test for As_2O_3 and Paris green.*

Heat the suspected powder in a small tube closed at one end; crystals of As_2O_3 are formed in the cool part of the tube.

336. *Describe the copper test for arsenic.*

Add solution of cupric sulphate, to which ammonium hydrate has been added until the precipitate formed just redissolves, to the suspected liquid; a green precipitate is formed if the reaction be neutral.

337. *What treatment must organic fluids be subjected to before testing for mineral poisons?*

The organic matter must be destroyed, as it interferes with the reactions to such an extent that, in fluids containing organic matter, it is impossible to be certain of the presence or absence of poisonous mineral matter. (See Manual, p. 96.)

ANTIMONY.

338. *What are the symbol and atomic weight of antimony?*

Symbol = Sb (from the Latin Stibium). Atomic weight = 120.

339. *What are its physical properties?*

It has a metallic appearance, crystalline texture, is tasteless, odorless, brittle, and easily pulverized; it melts at 450° (842° F.), and crystallizes on cooling; it may be distilled unchanged when air is excluded, but when sufficiently heated in air it burns brilliantly.

340. *What is the chief ore of antimony?*

The trisulphide, Sb_2S_3, known commercially as *black antimony* or *crude antimony*, and pharmaceutically as antimonii sulphidum, U. S.; antimonium nigrum, Br.

341. *For what purposes is antimony used in the arts?*

It enters into the composition of a number of important alloys: type-metal is an alloy of lead, tin, and antimony; britannia metal and the various antifriction alloys contain antimony. Its value in these alloys is, that it renders them hard and communicates the property of expanding on solidifying.

342. *What compound of antimony and hydrogen is known, and what are its properties?*

Antimoniuretted hydrogen, or hydrogen antimonide, SbH_3 having a composition corresponding to the hydrogen compounds of nitrogen, phosphorus, and arsenic. It is a colorless gas, resembling arseniuretted hydrogen in its properties and decompositions, except in that it is but slightly poisonous.

343. *What is butter of antimony, and what are its physical properties?*

It is the trichloride, $SbCl_3$, and forms at ordinary temperatures a semi-solid, yellow, crystalline mass, which fuses at 73° (164° F.), and boils at 223° (433°.4 F.). When exposed to the air it absorbs moisture and becomes first cloudy, then dark and oily.

344. *What is the action H_2O upon antimony trichloride?*

When diluted with a large quantity of H_2O it is decomposed, and a white, insoluble precipitate is formed. This was formerly known as *powder of Algaroth*, and is a mixture of trichloride and trioxide of antimony.

345. *How is the antimonii oxidum, U. S.; Br., prepared, and what is its composition?*

By decomposing the oxychloride, obtained by the reaction given in 344. It is the trioxide Sb_2O_3.

346. *What substance is formed when sulphuretted hydrogen is passed through a solution of an antimonial compound?*

Pentasulphide of antimony, Sb_2S_5: this is the "golden sulphuret of antimony." It is an orange colored, amorphous powder, readily soluble in ammonium sulphydrate solution and in hot HCl, but insoluble in ammonium hydrate solution.

347. *What is Kermes mineral?*

A mixture in varying proportions of the sulphides and trioxide of antimony, known pharmaceutically as antimonii oxysulphuretum, U. S. P.

(See Q. 854, 855.)

BORON.

348. *What are the symbol, atomic weight, and valence of boron?*

Its symbol is B; its atomic weight, 11. It is trivalent in all of its compounds.

349. *What is the most important compound of boron?*

Boracic acid—H_3BO_3—acidum boricum, U. S.

350. *What are the properties of boracic acid?*

White, glistening plates, unctuous to the touch; odorless; having a slightly bitter taste, and without corrosive or poisonous action; soluble in water. It is a valuable antiseptic. When heated to 80° (176° F.) it loses H_2O and forms metaboric acid, HBO_2; and at 100° (212° F.) it forms pyroboric acid, $H_2B_4O_7$, whose sodium salt is borax.

GROUP V.—CARBON GROUP.

CARBON	C	12.
SILICON	Si	28.

351. *State the common characters of the elements of this group.*

They are bivalent and quadrivalent. Their saturated oxides are anhydrides of dibasic acids. They are combustible. Each exists in three allotropic forms.

CARBON.

352. *What are the symbol and atomic weight of carbon?*

Its symbol is C, and its atomic weight is 12.

353. *How does carbon exist uncombined in nature?*

1. Almost pure, crystallized, as diamond. 2. Nearly pure, but less so than in diamond, as graphite or "black lead." 3. Mixed with more or less impurity, as the various kinds of coal.

354. *Name some of the artificial products composed almost entirely of carbon.*

1. Charcoal, obtained by subjecting wood to heat, with a limited supply of air. 2. Lampblack, obtained by the incomplete combustion of substances rich in carbon, such as resin,

natural gas, etc. 3. Coke, a porous substance remaining after heating certain kinds of coal, without contact with air. 4. Animal charcoal, obtained by subjecting animal matter to heat in closed vessels; contains a large amount of mineral salts or ash.

354*a*. *State the properties and uses of animal charcoal.*

It possesses the power of absorbing coloring matters and other substances from solutions. It is used in the refining of cane-sugar to remove the coloring matter, and for the same purpose in various pharmaceutical and chemical operations; care must be had, however, that loss be not sustained from the absorbing action of the charcoal on other substances, such as the alkaloids and various vegetable principles; indeed, purified animal charcoal has been used to separate alkaloids from solutions in which they are mixed with other substances. The deodorizing power of the crude charcoal is greater than that of the purified; the latter is to be used in the presence of any substance capable of acting on the mineral ingredients of the crude charcoal, notably in the presence of acids. (See Q. 545.)

355. *What is the action of oxygen upon carbon at high temperatures?*

The two elements have a great tendency to unite with each other with liberation of heat and light. If the supply of O be sufficient, an invisible compound, having the composition CO_2, is formed, while if the supply of O be insufficient, a gas, CO, is formed.

356. *What are the compounds of carbon with other elements called?*
Organic substances.

(FOR COMPOUNDS OF CARBON, see pp. 178 et seq.)

SILICON.

357. *What are the symbol and atomic weight of silicon?*
Its symbol is Si; its atomic weight 28.

357*a*. *Name some important compounds of silicon.*
Silicic anhydride, or silicon dioxide, SiO_2, and the corresponding acid, H_4SiO_4.

357*b*. *How do these substances exist in nature?*
They are very abundant. Silicic anhydride exists nearly pure as rock crystal, and less pure in the quartz entering into the composition of various rocks, sand, sandstone, and in a vast number of minerals. Silicic acid in combination, *i. e.*, silicates, constitutes a great number of minerals, and exists in animal and vegetable bodies and in many mineral waters.

CLASS III.—AMPHOTERIC ELEMENTS.

358. *What are the characteristics of the amphoteric elements?*

Their oxides combine with water, sometimes to form acids, sometimes to form bases. They are capable of displacing the hydrogen of the oxyacids to form oxysalts.

358*a*. *What name is used to designate the elements of this and the following class?*

The Metals.

358*b*. *Name the principal amphoteric elements.*

Gold, chromium, manganese, iron, aluminium, lead, bismuth, tin, and platinum.

GROUP I.—THE GOLD GROUP.

GOLD. Au. 197.

359. *What are the symbol and valence of gold?*

Au, from the Latin aurum. Gold forms two series of compounds, in one of which it is univalent, as in aurous chloride, $AuCl$, and in the other trivalent, as in auric chloride, $AuCl_3$.

359*a*. *By what agents is gold attacked?*

By free chlorine or bromine, by nitro-muriatic acid, from which chlorine is liberated. Mercury dissolves gold, forming a liquid amalgam. It is not attacked by any single acid or by any alkali.

359*b*. *What is the composition of United States gold coin?*

900 parts of gold, alloyed with 100 of copper. Jeweler's gold (18 karat) contains about $\frac{750}{1000}$ gold, the remainder being copper and silver in proportions varying with the color.

359*c*. *What compound of gold is used in the chemical and histological laboratories?*

Auric chloride, $AuCl_3$ = terchloride of gold.

359*d*. *Give the tests for the auric compounds.*

1. With H_2S, in neutral or acid solution, a dark-brown precipitate, insoluble in HNO_3 or in NH_4HS.

2. With stannous chloride and a little chlorine water, a purple-red precipitate.

3. With ferrous sulphate, a dark-brown precipitate.

GROUP II.—THE IRON GROUP.

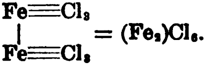
CHROMIUM	Cr	52.
MANGANESE	Mn	54.
IRON	Fe	56.

360. *Name the elements constituting the Iron group.*

Chromium, manganese, iron.

360*a*. *What are the valences of these elements?*

They are either bivalent or quadrivalent. They form two series of compounds, in one of which the bivalent atom occurs, as in $Fe''Cl_2$ or FeO. In compounds of the second series two atoms of the quadrivalent element combine, exchanging a valence between them to form a hexavalent group, as in



$$\begin{array}{l} Fe\equiv Cl_3 \\ | \\ Fe\equiv Cl_3 \end{array} = (Fe_2)Cl_6.$$

360*b*. *How are these two series distinguished by name?*

That containing the less proportion of the more electro-negative element or radical is distinguished by the termination *ous;* that containing the greater proportion by the termination *ic*. Thus $FeCl_2$ is ferr*ous* chloride, Fe_2Cl_6 ferric chloride.

CHROMIUM. Cr. 52.4.

361. *Give the formula of chromic anhydride.*

CrO_3. It is also known, improperly, as chromic acid—Acidum chromicum, U. S. P.

362. *How is it prepared and what are its uses?*

It is prepared by slowly adding 3 parts of sulphuric acid to 2 parts of a saturated solution of potassium dichromate; upon cooling, a mass of dark red needles of CrO_3 separate, and are freed from excess of H_2SO_4 by draining upon a porous tile. It is one of the most active oxidizing agents we have, and, as such, is used in the laboratory and medicinally as an escharotic. In dilute solution it is used as a hardening agent in histological laboratories.

363. *Explain the chemical difference between potassium chromate and dichromate.*

The former has the formula K_2CrO_4, and the latter $K_2Cr_2O_7$; they are therefore not salts of the same acid as are carbonate and bicarbonate of potassium, Na_2CO_3 and $NaHCO_3$, and the name bichromate tends to mislead. The chromate is a salt of chromic acid and the dichromate a salt of dichromic acid. From the constitution of these and other salts we may consider that chromic anhydride is capable of forming three acids:

$CrO_3 + H_2O = H_2CrO_4 =$ Chromic acid.
$2CrO_3 + H_2O = H_2Cr_2O_7 =$ Dichromic acid.
$3CrO_3 + H_2O = H_2Cr_3O_{10} =$ Trichromic acid.

None of these acids have been separated, they are only known in their salts.

364. *State the properties of* $K_2Cr_2O_7$.

It forms prismatic crystals of a fine orange red color; odorless; having a bitter, acrid taste; soluble in water. Poisonous. When mixed with sulphuric acid it forms a powerful oxidizing agent.

365. *What is "chrome yellow?"*

Lead chromate $PbCrO_4$.

MANGANESE. Mn. 54.

366. *Give an account of the most important oxide of manganese.*

Manganese dioxide, MnO_2, also known as black oxide or peroxide of manganese, is the chief ore of manganese and is used in the arts in obtaining chlorine by the decomposition of hydrochloric acid:

$$MnO_2 + 4HCl = MnCl_2 + 2H_2O + Cl_2$$

Manganese dioxide. Hydrochloric acid. Manganous chloride. Water. Chlorine.

When heated to redness it gives up part of its oxygen, and has been used for obtaining that element.

367. *What chemical interest has the oxide* Mn_2O_7 *?*

It is an anhydride whose corresponding acid, $H_2Mn_2O_8$, has not been separated, but some of the salts of which, called permanganates, are of importance.

368. *Give the formula and properties of potassium permanganate.*

$K_2Mn_2O_8$. It forms slender, prismatic crystals, of a purple color with a bronze-like reflection; inodorous, and having a sweetish, astringent taste. Quite soluble in water, the solution having a deep purple color, and a pink color when extremely dilute.

369. *How does $K_2Mn_2O_8$ act as a disinfectant?*

It is a very active oxidizing agent, and its action as a disinfectant is due to the oxidation of the organic matter which it causes. It forms the basis of Condy's and several other disinfecting fluids.

NOTE.—The corresponding sodium salt is now obtained more cheaply than the potassium salt, and answers as well as a disinfectant.

IRON. Fe. 56.

370. *How do cast iron, wrought iron, and steel differ from each other in composition?*

Mainly in the different quantity of carbon contained. Wrought iron is made from cast iron by burning out carbon; steel is prepared from wrought iron by causing it again to combine with carbon. Bessemer steel is made directly from cast iron by arresting the burning out of the carbon at the proper moment. Wrought iron is used in obtaining pharmaceutical preparations.

371. *What is Ferrum reductum, U. S. P.?*

A pure and finely divided iron obtained by reducing (see Q. 51), an oxide of iron by hydrogen:

$$\underset{\text{Ferric. oxide.}}{Fe_2O_3} + \underset{\text{Hydrogen.}}{3H_2} = \underset{\text{Iron.}}{Fe_2} + \underset{\text{Water.}}{3H_2O}$$

Reduced iron, or iron by hydrogen, as it is also called, should leave no residue when attracted by the magnet, such a residue is unreduced oxide.

372. *Give the formula and synonyms of ferric oxide.*

Fe_2O_3. Sesquioxide of iron, peroxide of iron, red oxide of iron, colcothar, rouge, Venetian red.

373. *What is the composition of iron rust?*

Chiefly a ferric hydrate, having the composition $2Fe_2O_3,3H_2O$, with small quantities of the carbonate,

374. *What is Ferri oxidum hydratum, U. S. P., and how is it prepared?*

Ferric hydrate, $Fe_2O_3,3H_2O$, prepared by adding ammonium hydrate to solution of ferric sulphate (Liq. ferri tersulphatis, U. S. P.):

$$\underset{\text{Ferric sulphate.}}{Fe_2(SO_4)_3} + \underset{\text{Ammonium hydrate.}}{6NH_4HO} = \underset{\text{Ferric hydrate.}}{Fe_2O_3,3H_2O} +$$

$$+ \underset{\text{Ammonium sulphate.}}{3(NH_4)_2SO_4}$$

The precipitated hydrate is collected upon a calico filter and washed.

375. *To what medical use is ferric hydrate put, and how does it act?*

As an antidote in arsenical poisoning. By producing the insoluble ferric arsenite.

376. *What decomposition occurs when this product is dried?*

It loses two molecules of water and is converted into the hydrate Fe_2O_3,H_2O=Ferri peroxidum hydratum, Br.

377. *Give the formula, method of preparation and use of ferrous sulphide.*

FeS. It is prepared by heating together sulphur and iron fillings, and is used in the laboratory to obtain sulphuretted hydrogen.

378. *Give the formula and synonyms of ferric chloride.*

Fe_2Cl_6. Ferri chloridum, U. S.; Br. Sesquichloride of iron, perchloride of iron.

379. *Give the U. S. P. method of its preparation.*

Iron is dissolved in hydrochloric acid, when ferrous chloride, $FeCl_2$, is formed; this is then boiled with nitric acid and excess of hydrochloric acid, by which $FeCl_2$, is converted into Fe_2Cl_6. As thus prepared it always contains an excess of acid.

380. *How may neutral ferric chloride be obtained?*

By heating iron in a current of chlorine, Fe_2Cl_6 condenses in the cool part of the tube.

381. *Give the formula and synonyms of ferrous sulphate.*

$FeSO_4$. Ferri sulphas, U. S.; Br. Sulphate of iron, green vitriol, copperas.

382. *State the method of its preparation and its properties.*

It is prepared by dissolving iron in dilute sulphuric acid and evaporating the solution to the point of crystallization. It forms apple-green crystals, containing 7Aq, odorless, having a sweetish, styptic taste, very soluble in water, insoluble in alcohol.

382*a*. *Give the analytical characters of the ferrous salts.*

1. With potassium hydrate, a greenish precipitate, insoluble in excess, and turning darker green and brown on exposure.

2. With potassium ferrocyanide, a white precipitate turning blue on exposure.

3. With potassium ferricyanide a dark blue precipitate.

383. *Give the analytical characters of the ferric salts.*

1. With potassium hydrate, a voluminous, red-brown precipitate.

2. With H_2S in acid solution, a milky precipitate of elementary sulphur.

3. With potassium ferrocyanide, a dark blue precipitate, insoluble in HCl, soluble in KHO.

4. With potassium (or ammonium) sulphocyanate, a deep red color, discharged on addition of mercuric chloride solution.

384. *What is produced on addition of ammonium sulphydrate solution to a solution of a ferrous or ferric salt?*

A black precipitate of ferric sulphide, readily soluble in HCl.

385. *What are* **Prussian blue** *and* **Turnbnll's blue?**

Prussian blue is ferric ferrocyanide, obtained by adding potassium ferrocyanide solution to a solution of a ferric salt (3, Q. 388). Turnbull's blue is ferrous ferricyanide, obtained by precipitating a solution of a ferrous salt with potassium ferricyanide (3, Q. 382.)

GROUP III. THE ALUMINIUM GROUP.

Glucinium	Gl	9
Aluminium	Al	27
Scandium	Sc	44
Gallium	Ga	69
Indium	In	113

386. *What are the common characters of the elements of this group?*

They form but a single series of compounds and salts, corresponding to the *ic* series of the preceding group, each of which contains a double atom of the element behaving as a hexavalent group. No compounds corresponding to the *ous* series of the second group are known. In other respects the terms of this group resemble those of the preceding closely.

ALUMINIUM. Al. 27.5.

387. *What is a notable physical property of aluminium.*

Its great lightness. Of all the elements usually called metals it is the lightest with the exception of the metals of the alkalies, which latter, however, cannot be kept unaltered in air. Aluminium is also quite tough and is very useful in the manufacture of metal appliances where lightness is an object.

388. *How does aluminium exist in nature?*

It is one of the most abundant of the elements. Its oxide, Al_2O_3, exists nearly pure as corundum, ruby and sapphire, and in a less pure form as emery. Its silicate, combined with other silicates, forms the different varieties of clay, mica, feldspar, etc.

389. *Explain the constitution of an alum.*

The sulphate of aluminium, in common with ferric, manganic, and chromic sulphates, possesses a great tendency to combine with the sulphates of potassium, sodium and ammonium, to form definite double salts, which are called alums; thus we have:

$Al_2(SO_4)_3,K_2SO_4$ = Aluminium potassium sulphate.

$Cr_2(SO_4)_3,(NH_4)_2SO_4$ = Chromic ammonium sulphate.

$Fe_2(SO_4)_3,Na_2SO_4$ = Ferric sodium sulphate.

We may therefore express the composition of an alum, in a general way, by the formula:

$$(R_2)^{vi}(SO_4)_3,M'_2SO_4$$

in which R represents an atom of Cr, Mn, Fe, Gl, Al, Sc, Ga or In; and M an atom of Li, Na, K, Cs, Rb or a group (NH_4).

390. *To what substance is the name "alum" commonly applied?*

To the aluminium ammonium sulphate, crystallized with 24 molecules of water of crystallization. $Al_2(SO_4)_3,(NH_4)_2SO_4 + 24\ Aq.$ It is also known as "ammonia alum" and is the alumen, Br. The alumen, U. S., is the corresponding potassium salt, formerly the "alum" of commerce, but now almost universally replaced by the ammonium salt.

391. *Wherein does alumen exsiccatum, U. S.; Br., differ from alumen?*

In having been subjected to heat, whereby the 24 molecules of water of crystallization are driven off. It is known commercially as "burnt alum."

392. *Give the tests for aluminium.*

1. With potash or soda, a white precipitate, soluble in excess of the precipitant.

2. With ammonium hydrate, a white precipitate, almost insoluble in excess.

3. With disodic phosphate, a white precipitate, soluble in HCl, HNO_3, or H_2SO_4.

4. A solid compound of aluminium, heated on charcoal by the blowpipe flame in presence of cobalt nitrate, assumes a dark sky-blue color.

GROUP V.

LEAD..............207..............Pb

393. *Give the symbol, atomic weight, and valence of lead.*

Symbol = Pb (Latin Plumbum). Atomic weight = 207. It is bivalent in most of its compounds; in some quadrivalent.

394. *What mineral is the most important ore of lead?*

A native sulphide, PbS, called galena; it frequently contains a considerable quantity of silver.

395. *Name some of the alloys into whose composition lead enters.*

Type-metal, pewter, Britannia metal, solder, shot. The last-named contains arsenic.

396. *Describe the physical properties of lead.*

A bluish gray metal; brilliant upon freshly cut surfaces; very soft and pliable; not readily malleable or ductile; a poor conductor of electricity; a better conductor of heat. Specific gravity = 11.5.

397. *Describe the actions of HCl, of HNO_3, and of H_2SO_4 upon Pb.*

It is partly dissolved as $PbCl_2$ by strong HCl, particularly if heated. It is readily dissolved by HNO_3 as lead nitrate. Strong H_2SO_4 attacks Pb, dissolving a portion as lead sulphate which is, however, precipitated as a white powder when H_2O is added. Dilute H_2SO_4 produces a white coating of lead sulphate upon the metal.

See Q. 80

398. *What is the formula of lead monoxide, and under what other names is it known?*

PbO. Plumbi oxidum, U. S.; Br.; litharge; massicot.

399. *How is it prepared, and what are its principal properties?*

It is prepared by heating lead in a current of air; direct union of the lead and oxygen takes place, forming a yellow powder known as massicot; when heated to redness, this fuses, and, on cooling, forms coppery, crystalline scales, in which form it is known as litharge. Litharge should not be fused in an earthen crucible, as it combines with the silicic anhydride to form a fusible lead silicate, and thus perforates the crucible. Litharge is sparingly soluble in water; the solution absorbs CO_2 from the air, and lead carbonate is precipitated; it is also soluble in solutions of the hydrates of potassium, sodium, and calcium. It is a powerful base.

400. *For what purposes is PbO used in the arts?*

In the manufacture of glass, white lead, red lead, acetate of lead, for communicating a drying power to oils, in making the various plasters used in pharmacy. A solution of PbO in lime-water is used as a hair-dye, the lead, combining with sulphur from the hair, forms the black lead sulphide.

401. *Give the formula and other names of lead dioxide.*

PbO_2. Puce colored oxide of lead; peroxide of lead; plumbic anhydride.

402. *Why is the name plumbic anhydride given it?*

Because it is the anhydride of a weak acid, having the formula H_2PbO_3. Although the acid has not been obtained, several of its salts are known, *e.g.*, K_2PO_3 = potassium plumbate.

403. *How is red lead obtained, and under what other name is it known?*

Litharge is further oxidized by roasting it in contact with air. It is known as red oxide of lead; minium.

404. *What is the composition of red lead?*

It has not a constant composition, being a mixture, in various proportions, of two substances; one the lead salt of plumbic acid (see Q. 402), or lead plumbate, $PbPbO_3$, and the other lead monoxide, PbO; it usually has the composition $PbPbO_3 + PbO$.

405. *What compound of lead with a mineral acid is soluble in water, and how is it obtained?*

The nitrate, $Pb(NO_3)_2$. It is formed by dissolving the oxides or carbonate of lead in nitric acid:

$$\underset{\text{Litharge.}}{PbO} + \underset{\text{Nitric acid.}}{2HNO_3} = \underset{\text{Lead nitrate.}}{Pb(NO_3)_2} + \underset{\text{Water.}}{H_2O}$$

406. *What are the uses of lead nitrate?*

It is used in preparing the iodide. It enters into the composition of many disinfecting fluids. Ledoyen's disinfectant is a solution of this substance of the strength of a drachm to the fluid ounce.

407. *Give the formula of lead iodide, and its method of formation.*

PbI_2. It is obtained by adding solution of potassium iodide to solution of lead nitrate:

$Pb(NO_3)_2$	$+$	$2KI$	$=$	$2KNO_3$	$+$	PbI_2
Lead nitrate.		Potassium iodide.		Potassium nitrate.		Lead iodide.

408. *State the properties of lead iodide.*

It forms a lemon-yellow powder, very sparingly soluble in cold water, more soluble in hot water, from which latter solution it separates in crystals; its solution is colorless.

409. *What yellow pigments are oxychlorides of lead?*

Cassel, Paris, Verona, and Turner's yellows.

410. *What is chrome yellow?*

Neutral lead chromate.

411. *Give the chemical and pharmaceutical names and formula of sugar of lead.*

Neutral lead acetate; Plumbi acetas, U. S.; Br. $Pb(C_2H_3O_2)_2 + 3Aq$. It is sometimes called salt of Saturn.

412. *State the prominent properties of neutral lead acetate.*

It crystallizes in large, colorless prisms. It is sweetish in taste, with a metallic after-taste. With water and alcohol it forms solutions which are acid in reaction.

413. *Why are lead acetate and zinc sulphate incompatible?*

Because the Pb is more or less completely precipitated as lead sulphate, which is insoluble:

$$Pb(C_2H_3O_2)_2 + ZnSO_4 = PbSO_4 + Zn(C_2H_3O_2)_2.$$

The solution still contains zinc acetate.

414. *Why are lead acetate and the vegetable astringents incompatible?*

Because the tannic acid of the astringent combines with the lead to produce an insoluble lead tannate.

415. *What pharmaceutical preparation contains a basic lead acetate, and how is it prepared?*

Liquor plumbi subacetatis U. S.; Br.; also known as Goulard's extract.

It is prepared by boiling a solution of lead acetate with litharge.

416. *What is* white lead?

A basic lead carbonate.

417. *What is meant by a* basic *or* sub *salt?*

A compound of the normal salt with a hydrate or oxide of the metal. Thus the normal lead carbonate being $PbCO_3$; the basic carbonate constituting the greater part of white lead is $(PbCO_3)_2,PbH_2O_2$.

418. *Give the analytical reactions of lead.*

1. With H_2S in acid solution, a black precipitate, insoluble in alkaline sulphides.

2. With ammonium sulphydrate, a black precipitate, insoluble in excess.

3. With HCl a white precipitate if the solu-

tion be not too dilute. On heating, the precipitate is dissolved, and again deposited as a crystalline sediment on cooling.

4. With ammonium hydrate, a white precipitate.

5. With H_2SO_4, a white precipitate.

6. With potassium iodide, a yellow precipitate.

7. With potassium chromate, a yellow precipitate.

8. Iron and zinc separate the metal from solutions of its salts.

419. *Describe the prominent symptoms of acute lead poisoning.*

Metallic taste; dryness of the throat; thirst; severe colicky abdominal pains, referred particularly to the umbilical region, and relieved by pressure; pulse very feeble and slow; great prostration; constipation; urine scanty and red; violent cramps; paralysis of the lower extremities; convulsions; and tetanic spasms.

420. *What is the best antidote in acute lead poisoning?*

Magnesium sulphate, which brings about the formation of the insoluble lead sulphate, while the purgative action of the magnesia is also useful; it should be preceded by an emetic, or by the use of the stomach-pump.

421. *What is the prognosis in acute lead-poisoning?*

Favorable; about 80 per cent recover.

422. *Give some of the prominent causes of chronic lead-poisoning.*

The contamination of drinking water from lead pipes. Contamination of articles of food or drugs by contact with leaden vessels, or from being inclosed in tinfoil containing an excess of lead. Drinking beer, cider, etc., which has been drawn through leaden pipes, or allowed to stand in pewter vessels. The ingestion or constant handling of lead or its compounds, as the acetate, nitrate, carbonate (white lead—painter's colic), Goulard's extract, etc. The use of hair-dyes containg lead.

GROUP VI.

BISMUTH........ ....207.5..........Bi.

423. *What are the symbol, atomic weight, and valence of Bi?*

Symbol = Bi. Atomic weight = 207.5. It is trivalent.

424. *What are its physical properties?*

A white, metallic substance, having peculiar reddish and greenish reflections; very brittle; fuses at 268° (514° F.); expands considerably on cooling; crystallizes in cubes; forms alloys with metals, some of which are fusible at very low temperatures.

425. *How is bismuth purified for use in pharmacy, and what is the object of the purification?*

Commercial bismuth is almost always contaminated with arsenic, to separate which it is fused with about one-fifth its weight of potassium nitrate.

426. *What is the action of nitric acid on bismuth?*

When bismuth is treated with nitric acid it is dissolved, brown fumes being given off; on cooling, white crystals of bismuth nitrate, $Bi(NO_3)_3$, form.

427. *What is the action of water upon bismuth nitrate?*

When the above solution is diluted with water, a white precipitate is formed; this is bismuthyl nitrate, or a nitrate of the group (BiO) which behaves as an atom of an univalent metal:

$$\underset{\textbf{Bismuth nitrate.}}{Bi(NO_3)_3} + \underset{\textbf{Water.}}{H_2O} = \underset{\textbf{Bismuthyl nitrate.}}{BiO(NO_3)} + \underset{\textbf{Nitric acid.}}{2HNO_3}$$

This new substance is what is known as subnitrate of bismuth, bismuthi subnitras, U. S.; Br. The process by which the salt is prepared pharmaceutically is more complicated, the object being the separation of arsenic.

428. *What are the so-called* oxysalts *or* subsalts *of bismuth?*

They are salts of the group (BiO)′, bismuthyl, which always behaves as an atom of an univalent metal; thus we have:

	Bismuth.	**Bismuthyl.**
Chloride	$BiCl_3$	$(BiO)Cl$.
Bromide	$BiBr_3$	$(BiO)Br$.
Nitrate.	$Bi(NO_3)_3$	$(BiO)NO_3$.
Sulphate	$(Bi)_2(SO_4)_3$	$(BiO)_2SO_4$.
Carbonate	$(Bi)_2(CO_3)_3$	$(BiO)_2CO_3$.

429. *Describe the tests for bismuth.*

1. With H_2O, a white precipitate, except in presence of free HCl, HNO_3, or H_2SO_4.

2. With H_2S, a black precipitate, insoluble in alkaline sulphides.

3. With potassium, sodium or ammonium hydrate, a white precipitate, turning yellow when the liquid is boiled.

4. With potassium ferrocyanide, a yellowish precipitate.

5. With potassium ferricyanide, a yellowish precipitate.

6. With potassium iodide, a brown precipitate, soluble in excess.

GROUP VII.—THE TIN GROUP.

TITANIUM	50.	Ti.
ZIRCONIUM	90.	Zr.
TIN	117.7	Sn.

TIN.

430. *What are the symbol, atomic weight, and valence of tin?*

Its symbol is Sn (Latin Stannum); its atomic weight is 118. It forms two series of compounds, in one of which it is bivalent, and in the other quadrivalent.

431. *For what purposes is tin used in the arts?*

1. For protecting iron from the action of air and moisture; the various "tin" articles used in the household are made of iron covered with a thin layer of tin. 2. For manufacturing tin foil. 3. In the silvering of looking-glasses.

432. *What are meant by* stannous *and* stannic *compounds?*

Those compounds of tin in which that element is bivalent are called stannous: $SnCl_2$ = stannous chloride; those in which it is quadrivalent are called stannic: $SnCl_4$ = stannic chloride.

433. *How is stannous chloride obtained, and what are its uses?*

By dissolving tin in hydrochloric acid with the aid of gentle heat. It is a strong reducing agent, and is used in calico printing, and in the laboratory as a reagent for gold and mercury.

434. *Give the analytical characters of the stannous compounds.*

1. With ammonium hydrate, a white precipitate, turning olive brown when the liquid is boiled.

2. With H_2S, a dark-brown precipitate, soluble in alkaline sulphides, in potassium hydrate, and in hot H_2O.

3. With mercuric chloride, a white precipitate, turning gray and black.

GROUP VIII.—THE PLATINUM GROUP.

PALLADIUM	105.7	Pd.
PLATINUM	194.4	Pt.

PLATINUM.

435. *How does platinum behave toward the mineral acids?*

It is indifferent toward any single mineral acid. Aqua regia dissolves it readily with formation of platinic chloride, $PtCl_4$.

436. *To what uses is metallic platinum put?*

In making crucibles, dishes, and other vessels destined to bear a high heat without fusion; and in which acids may be heated. Large retorts made of this metal are used in the concentration of sulphuric acid.

437. *What precautions are to be had in using platinum vessels?*

Although not attacked by single acids, platinum vessels are injured by many substances. The metal is attacked by nitromuriatic acid, or any substance liberating chlorine. Platinum has agreat tendency to alloy with other metals; therefore, no metal or easily reducible oxide should be heated in contact with it. The alkalies and alkaline carbonates and, under certain conditions, the alkaline phosphates attack platinum; when these substances are to be heated, silver vessels should be used, care being taken, however, that the heat be not pushed beyond the fusing point of that metal. Platinum vessels should never be heated over an alcohol or coal fire, because when so heated the metal becomes blackened and brittle.

438. *What is the valence of platinum?*

It forms two series of compounds, in one of which it is bivalent, as in $Pt''Cl_2$ = platinous chloride; and in the other quadrivalent, as in $Pt^{iv}Cl_4$ = platinic chloride.

439. *For what purpose is platinic chloride used in chemistry?*

As a test for the presence of the compounds of potassium and ammonium, with which it forms insoluble, yellow, crystalline compounds. And as a test for certain alkaloids.

CLASS IV.—BASYLOUS ELEMENTS.

440. *What are the characteristics of the basylous elements?*

Their oxides combine with water to form bases, never to form acids. They are capable of displacing the hydrogen of the oxyacids to form oxysalts.

441. *What elements are designated as* metals?

Those which are capable of displacing the hydrogen of oxyacids to form oxysalts. The amphoteric and basylous elements.

442. *Name the principal basylous elements.*

Lithium, sodium, potassium, silver, calcium, barium, magnesium, zinc, copper, mercury.

GROUP I.—THE ALKALINE METALS.

Lithium	Li	7
Sodium	Na	23
Potassium	K	39
Rubidium	Rb	85.3
Cæsium	Cs	133
Silver	Ag	108

443. *What term is used to designate the elements of this group?*

The alkaline metals.

NOTE.—Silver is not usually included in this group. It differs from the other members entirely in its physical properties and in being much less alkaline; but it resembles them in its valence and in the nature of its compounds.

444. *What are the common characters of the members of this group?*

Each forms a single chloride and one or more oxides. Their hydrates, M′HO, are strongly basic. They are univalent.

445. *To what elements was the name* metalloid *first applied, and why?*

To potassium and sodium. The word metalloid signifies "like a metal," and was given to these elements at the time of their discovery, because, although resembling the then known metals in some physical characters, they differ from them in others.

LITHIUM.

446. *What are the symbol and atomic weight of lithium?*

Its symbol is Li; its atomic weight 7.

447. *What compounds of lithium are used in medicine?*

The bromide, LiBr = Lithii bromidum U. S.; and the carbonate Li_2CO_3 = Lithii carbonas U. S.; Br.

SODIUM.

448. *What are the symbol and atomic weight of sodium?*

Its symbol is Na (Latin, Natrium); its atomic weight 23.

449. *What are the physical properties of elementary sodium?*

When pure, it is a brilliant, silver-white metal, crystallizing in cubes. As commonly met with, it is a bluish metal, coated with a brown film. It is lighter than water (sp. gr. 0.972). It fuses at 95°.6 (204°.1 F.), and may be distilled in an atmosphere of hydrogen. It is waxy in consistency at the ordinary temperature.

450. *What is the action of sodium on water?*

If a fragment of sodium be thrown upon water, it floats upon the surface, and gradually disappears, with a hissing noise, while hydrogen is given off, and caustic soda is formed:

$$\underset{\text{Sodium.}}{Na_2} + \underset{\text{Water.}}{2H_2O} = \underset{\text{Sodic hydrate.}}{2NaHO} + \underset{\text{Hydrogen.}}{H_2}$$

Sodium is similarly converted into NaHO by exposure to damp air, hence it should be kept in some liquid free from oxygen, as benzine, or in closely sealed vessels.

451. *How is metallic sodium prepared?*

By heating a mixture of dry sodium carbonate, chalk, and charcoal to a white heat.

452. *What are the chemical name and formula of caustic soda?*

Sodium hydrate—NaHO.

453. *Describe the prominent properties of NaHO.*

It is a hard, white, amorphous solid, very soluble in water, forming solutions which are intensely alkaline in reaction.

It is a powerful base, neutralizing acids with formation of sodium salts, and a strong corrosive. On exposure to air, it absorbs carbon dioxide, and is converted into the carbonate. A strong solution of NaHO is called "Soda lye."

454. *What is common salt?*

Sodium chloride, NaCl.

455. *Where does NaCl occur in nature?*

In the mineral world, deposited in the solid form, as "rock salt;" in soils; and in solution, in varying quantities, in all natural waters. In all animal tissues and fluids, and in less quantity in vegetable tissues.

456. *What are the chief uses of NaCl in the arts?*

As a starting-point in the manufacture of most of the sodium compounds, hydrochloric acid, chlorine, bleaching powder; in the preservation of meats, fish, etc., and in glazing pottery.

457. *What are the chief impurities of commercial salt?*

Chlorides of calcium and magnesium. They communicate to the salt a somewhat bitter taste, and the property of absorbing moisture from the air.

458. *What functions does NaCl perform in the animal economy?*

It aids in the phenomena of osmosis throughout the body, aids in holding certain of the albuminoids in solution; and is the source from which the hydrochloric acid of the gastric juice is probably derived.

459. *How is it eliminated?*

By all the excretions, principally in the urine.

(See Manual, p. 131.)

460. *What data are required to calculate the quantity of bromine in 100 parts of sodium bromide?*

1st. Its formula—NaBr. 2d. The atomic weight of sodium—23, and that of bromine—80; the sum being of course the molecular weight of NaBr = 103. 3d. Whether or no the substance in the condition used contains water of crystallization or not.

NOTE.—This last point must not be lost sight of. NaBr contains no water of crystallization, and if we weigh out 103 parts, we will have 80 parts Br.; but suppose it contained 1 molecule of water of crystallization, its formula would then be NaBr + Aq, and to get 80 parts Br we would have to take 23 + 80 + 2 + 16 = 121 parts.

461. *Calculate how much iodine there is in 100 parts of sodium iodide.*

Its formula is NaI, and it contains no water of crystallization; its molecular weight is, therefore, 23 + 127 = 150, or 150 parts NaI contain 127 parts I. Therefore:

$$150 : 100 :: 127 : x \qquad x = 84.66$$

462. *Give the formula and synonyms of sodium nitrate.*

$NaNO_3$. Chili saltpetre; cubic nitre; sodæ nitras, U. S.; Br.

463. *Give the formulæ and names of the sulphates of sodium.*

Monosodic sulphate, $NaHSO_4$, also known as acid sodium sulphate or bisulphate of sodium. Disodic sulphate, Na_2SO_4, also known as neutral sodium sulphate, Glauber's salt, sodii sulphas (U. S.), sodæ sulphas (Br.).

464. *Where does disodic sulphate occur in the animal economy?*

In all tissues and fluids, except the milk, bile, and gastric juice.

465. *Give the formulæ and names of the phosphates of sodium.*

Monosodic phosphate, NaH_2PO_4 = acid sodium phosphate. Disodic phosphate, Na_2HPO_4 = phosphate of soda; sodii phosphas (U. S); sodæ phosphas (Br.). Trisodic phosphate, Na_3PO_4 = basic phosphate of soda.

The first named crystallizes with 1 Aq., the last two with 12 Aq.

466. *In what portions of the animal body do the phosphates of sodium occur?*

In all parts.

467. *In what animal fluids does the trisodic phosphate predominate, and what function does it perform?*

In the blood; in greater proportion the more strictly animal the diet. The alkalinity of the blood is largely due to this salt.

468. *In what relative proportions do the phosphates of sodium and potassium occur in the body?*

They accompany each other in all parts; the sodium salt being much more abundant in all situations except in the blood-corpuscles and in the muscular tissue, in which the potassium compounds predominate.

469. *To what is the acid reaction of human urine due?*

To the presence of monosodic and monopotassic phosphates.

470. *How are phosphates produced in the animal body?*

By the processes of disassimilation of nerve-tissue, which contains phosphorized organic substances, the oxidation of whose phosphorus is attended by the formation of phosphates.

471. *What are the* alkaline phosphates *of the urine?*

The phosphates of sodium and potassium. They are so called because they are the phosphates of the "alkaline metals," although they are acid salts.

472. *What is borax?*

Sodium pyroborate, or tetraborate, $Na_2B_4O_7 + 10$ Aq.

473. *What sodium salt exists in Liq. Sodæ Chlorinatæ, U. S.; Br.?*

Sodium hypochlorite, NaClO.

474. *Give the names and formulæ of the carbonates of sodium.*

Monosodic carbonate, $NaHCO_3$, also called bicarbonate of soda, cooking soda, acid carbonate of soda, sodii bicarbonas, U. S., and sodæ bicarbonas, Br. Disodic carbonate, $NaCO_3$, also called carbonate of soda, washing soda, sal soda, soda, soda crystals, sodii carbonas, U. S., and sodæ carbonas, Br.

The former crystallizes without Aq., the latter with 10 Aq.

475. *What is the reaction of solutions of these carbonates?*

It is distinctly alkaline; that of the carbonate being more markedly so than that of the bicarbonate.

476. *Of what importance is the disodic carbonate in the arts?*

It is manufactured in large quantities, and is used in many important industrial operations, *e. g.*, glass and soap manufacture, calico printing, and as a starting-point in obtaining the various compounds of sodium. It is used in the laundry to soften hard water.

477. *How are the carbonates of potassium and sodium formed in the economy, and what is their function?*

By the oxidation of sodium and potassium salts of other organic acids existing in plants. Their main function is the preservation of alkaline reaction of the circulating fluids in the herbivora, and to a greater or less degree in man. The administration of vegetable acids communicates an alkaline reaction to the urine by reason of their oxidation in the body with formation of carbonates of sodium and potassium.

478. *To what substance does the name* salaeratus *properly apply, and to what is it commonly applied?*

It was originally used to designate potassium bicarbonate, but at present the article universally sold and used under the name "salaeratus" is monosodic carbonate.

479. *For what purpose and how is monosodic carbonate used in baking?*

As a source of carbon dioxide gas, whose liberation "raises" the bread. It is used either alone or combined with some acid salt.

480. *Why should it not be used alone?*

Because under the influence of heat it is decomposed according to the equation:

$$2NaHCO_3 = Na_2CO_3 + H_2O + CO_2,$$

and the product of the baking conseqently contains the strongly alkaline disodic carbonate.

481. *Write the equations representing the actions of tartrate, alum and phosphate baking powders.*

1. $$\underset{\text{Monopotassic tartrate.}}{HKC_4H_4O_6} + \underset{\text{Monosodic carbonate.}}{NaHCO_3} = \underset{\text{Sodium-potassium tartrate.}}{NaKC_4H_4O_6} +$$
$$+ \underset{\text{Water.}}{H_2O} + \underset{\text{Carbon dioxide.}}{CO_2}$$

2. $$\underset{\text{Aluminium Ammonium sulphate.}}{Al_2(SO_4)_3,(NH_4)_2SO_4} + \underset{\text{Monosodic carbonate.}}{6NaHCO_3} =$$
$$= \underset{\text{Diammonic sulphate.}}{(NH_4)_2SO_4} + \underset{\text{Disodic sulphate.}}{3Na_2SO_4} + \underset{\text{Aluminium hydrate.}}{Al_2H_6O_6} + \underset{\text{Carbon dioxide.}}{6CO_2}$$

3. $$\underset{\text{Monosodic phosphate.}}{NaH_2PO_4} + \underset{\text{Monosodic carbonate.}}{NaHCO_3} = \underset{\text{Disodic phosphate.}}{Na_2HPO_4} +$$
$$+ \underset{\text{Water.}}{H_2O} + \underset{\text{Carbon dioxide.}}{CO_2}$$

POTASSIUM.

482. *What are the symbol and atomic weight of potassium?*

Its symbol is K (Latin, Kalium); its atomic weight is 39.

483. *What are the physical properties of potassium?*

A silver white, metallic body; soft at ordinary temperatures, melts at 62°.5 (144°.5 F.), and at red heat boils, with formation of green vapors. It is lighter than water.

484. *What is the action of potassium on water and air?*

Potassium decomposes water with great energy:

$$\underset{\text{Potassium.}}{K_2} + \underset{\text{Water.}}{2H_2O} = \underset{\substack{\text{Potassium.}\\\text{hydrate.}}}{2KHO} + \underset{\text{Hydrogen.}}{H_2}$$

The action is so violent that flame and a slight explosion are produced; K has also a great tendency to unite with oxygen, and, if this be perfectly dry, potassium oxide, K_2O, is formed. When potassium is exposed to air, its surface is rapidly coated with a yellowish-white layer of KHO. In order to preserve the metal, it must be kept under some substance containing no oxygen, as benzine.

485. *What is the constitution of potassium hydrate?*

It is a molecule of water in which one atom of hydrogen has been replaced by one atom of potassium.

$$\begin{array}{ccccccc} 2\left.\begin{matrix}H'\\ H'\end{matrix}\right\}O'' & + & \left.\begin{matrix}K\\ K\end{matrix}\right\} & = & 2\left.\begin{matrix}K\\ H\end{matrix}\right\}O & + & \left.\begin{matrix}H\\ H\end{matrix}\right\} \\ \begin{matrix}\text{2 molecules}\\ \text{water.}\end{matrix} & & \begin{matrix}\text{1 molecule}\\ \text{potassium.}\end{matrix} & & \begin{matrix}\text{2 molecules}\\ \text{potassium}\\ \text{hydrate.}\end{matrix} & & \begin{matrix}\text{1 molecule}\\ \text{hydrogen.}\end{matrix} \end{array}$$

or, in other words, it is a molecule composed of one atom of bivalent oxygen united with one of each of the univalent atoms, hydrogen and potassium.

486. *Under what other names is potassium hydrate known?*

Caustic potash; potassa, U. S.; potassa caustica, Br.; potassa fusa; potassa alba.

487. *What are the physical properties of KHO?*

It is a hard, white solid (usually in the shape of sticks, about one-quarter inch in diameter and six inches long), opaque, brittle; melts at a dull red heat; very soluble in water, less so in alcohol. Has a strong, soapy taste, even in dilute solution.

488. *Why should KHO and its solutions be protected from air?*

Because they rapidly absorb carbonic anhydride, forming potassium carbonate, and in course of time the hydrate will be entirely replaced by the carbonate.

489. *State some of the chemical properties of KHO.*

It is a powerful base, entering readily into reaction with acids to form salts:

$$\begin{array}{ccccccc} \left.\begin{matrix}K\\ H\end{matrix}\right\}O & + & \left.\begin{matrix}NO_2\\ H\end{matrix}\right\}O & = & \left.\begin{matrix}H\\ H\end{matrix}\right\}O & + & \left.\begin{matrix}NO_2\\ K\end{matrix}\right\}O \\ \begin{matrix}\text{Potassium}\\ \text{hydrate.}\end{matrix} & & \begin{matrix}\text{Nitric}\\ \text{acid.}\end{matrix} & & \text{Water.} & & \begin{matrix}\text{Potassium}\\ \text{nitrate.}\end{matrix} \end{array}$$

It has a strong alkaline reaction, and is a powerful caustic, dissolving most animal tissues. In concentrated solution it attacks glass. Its solution dissolves sulphur, phosphorus, chlorine, bromine, and iodine, forming with these elements compounds soluble in water.

490. *What is the action of KHO on ammonium salts?*

Being a stronger base than ammonium, it decomposes the ammoniacal salt with formation of a potassium salt, water, and ammonia:

$$\underset{\text{Ammonium nitrate.}}{(NH_4)NO_3} + \underset{\text{Potassium hydrate.}}{KHO} = \underset{\text{Potassium nitrate.}}{KNO_3} + \underset{\text{Ammonia.}}{NH_3} +$$

$$+ \underset{\text{Water.}}{H_2O}$$

491. *What is the action of solution of KHO on solutions of most metallic salts?*

It decomposes the salt with formation of the corresponding potassium salt and a metallic hydrate:

$$\underset{\text{Cupric sulphate.}}{CuSO_4} + \underset{\text{Potassium hydrate.}}{2KHO} = \underset{\text{Potassium sulphate.}}{K_2SO_4} + \underset{\text{Cupric hydrate.}}{CuH_2O_2}$$

Some of the hydrates being of characteristic color, and insoluble in water, solution KHO is used as a test reagent.

492. *What is the composition of potassium chloride, and where does it exist in nature?*

KCl. It is very widely distributed in mineral, vegetable, and animal nature. As a double chloride of potassium and magnesium it constitutes a mineral called *carnallite*, which is the chief mineral source of the potassium compounds. It is found in all animal tissues and fluids, accompanying the corresponding sodium compound, but in much less quantity; it is most abundant in the red blood-corpuscles.

493. *What are the composition and physical properties of potassium bromide?*

KBr. It forms milk-white cubes, containing no water of crystallization; unaltered by exposure to air; odorless; having a peculiar salty taste. Soluble in 1½ parts of cold water, and easily soluble in alcohol.

494. *How much bromine is contained in* 100 *parts KBr, and how is this ascertained?*

The molecule of KBr is composed of one atom of potassium, weighing 39, and one atom of bromine, weighing 80; the weight of the molecule is therefore $39 + 80 = 119$; obviously, 119 parts by weight of KBr contain 80 parts by weight of Br, and by the proportion

$$119 : 100 :: 80 : x$$

we find that 100 parts by weight of KBr contain 67.23 parts by weight of Br.

495. *What is the action of chlorine upon KBr?*

It decomposes it with formation of the chloride and liberation of bromine:

$$\underset{\text{Chlorine.}}{Cl_2} + \underset{\text{Potassium bromide.}}{2KBr} = \underset{\text{Potassium chloride.}}{2KCl} + \underset{\text{Bromine.}}{Br_2}$$

496. *What reaction takes place between solutions of KBr and those of mercurous, lead, or silver salts?*

The bromine unites with the mercury, lead, or silver to form corresponding bromides, which are insoluble. With solution of mercuric chloride (corrosive sublimate) it gives no precipitate; if it do, the bromide is contaminated with potassium iodide.

497. *What are the composition and physical properties of potassium iodide?*

KI. It forms milk-white cubes without water of crystallization; odorless; having a sharp, bitterish, saline taste; unaltered by exposure to air (when it becomes damp it is impure). Very soluble in water, less so in alcohol; the solutions being clear, colorless, and neutral.

498. *Why is KI incompatible with the insoluble mercurials?*

Because it renders them soluble to a greater or less extent, and consequently much more active.

499. *What takes place when KI and metallic salts are combined?*

The formation of the potassium salt of the acid and iodide of the other metal.

$$\underset{\text{Lead acetate.}}{Pb(C_2H_3O_2)_2} + \underset{\substack{\text{Potassium}\\\text{iodide.}}}{2KI} = \underset{\substack{\text{Potassium}\\\text{acetate.}}}{2KC_2H_3O_2} + \underset{\substack{\text{Lead}\\\text{iodide.}}}{PbI_2}$$

This reaction is important in the cases of lead, bismuth, copper, and silver.

500. *What is the action of chlorine, bromine, or fuming nitric acid upon KI?*

The salt is decomposed with liberation of free iodine.

501. *What are the formula and common names of potassium nitrate?*

KNO_3. Potassii nitras, U. S.; Potassæ nitras, Br.; saltpetre; nitre.

502. *What is the origin of KNO_3?*

It has its origin in the oxidation of animal or vegetable substances rich in nitrogen, in the presence of potassium. It is thus formed both naturally and artificially. The commercial salt is usually very impure.

502*a*. *What are the chief uses of KNO_3?*

In the manufacture of nitric and sulphuric acids, and of gun powder; in packing beef and pork. In the laboratory it is used as an oxidizing agent.

503. *What are the formula and physical properties of potassium chlorate?*

$KClO_3$.—Occurs in transparent, colorless plates, without water of crystallization; permanent in air; odorless; has a cool, salty taste; soluble in 30 parts of cold water; sparingly soluble in alcohol. Its aqueous solution is colorless and neutral in reaction.

504. *What decomposition does $KClO_3$ undergo when heated?*

It first fuses, and at higher temperatures is decomposed, yielding oxygen and potassium chloride:

$$\underset{\text{Potassium chlorate.}}{2KClO_3} = \underset{\text{Potassium chloride.}}{2KCl} + \underset{\text{Oxygen.}}{3O_2}$$

This is the reaction generally utilized for the production of oxygen.

505. *What precaution is to be had in dispensing $KClO_3$?*

It should never be combined with any organic or easily oxidizable substance, or with any strong acid or acid sulphate. With these substances, $KClO_3$ is readily decomposed, forming substances which are violently explosive.

NOTE.—It is safest only to use this compound in simple aqueous solution, as the formation of these explosive substances frequently occurs under imperfectly studied conditions. The manufacture of chlorate of potassium lozenges is a dangerous operation, and disastrous explosions have been traced to it.

506. *What is Javelle Water?*

A solution of potassium hypochlorite, $KClO$; a compound which is only known in solution, and is formed by passing chlorine through a cold solution of potassium carbonate. It is a clear, colorless liquid, having an odor of chlorine and a bleaching action upon vegetable colors. It is used in removing stains from fabrics.

507. *Give the names and formulæ of the sulphates of potassium.*

Monopotassic sulphate, $KHSO_4$, hydropotassic sulphate, acid sulphate, bisulphate of potassium. Dipotassic sulphate, K_2SO_4, sulphate of potassium, potassii sulphas U. S.; potassæ sulphas (Br.).

508. *Give the names and formulæ of the carbonates of potassium.*

Monopotassic carbonate, $KHCO_3$ = hydro-potassic carbonate, bicarbonate, potassii bicarbonas, U. S., potassæ bicarbonas, Br., sal aeratus. Dipotassic carbonate, K_2CO_3 = salt or tartar; pearl ash, potash, potassii carbonas, U. S., potassæ carbonas, Br.

509. *Describe the analytical characters of lithium, sodium, and potassium.*

They are most readily detected by the colors which they communicate to the blue Bunsen flame: Lithium, a bright red; sodium, yellow; potassium, violet. The latter is only visible in the presence of Na when the flame is observed through a blue glass, or a glass vessel filled with dilute indigo solution.

Sodium salts form a white precipitate, becoming crystalline on standing, with potassium pyroantimoniate solution.

Potassium chloride gives a yellow, crystalline precipitate with platinic chloride solution. The liquid must not contain ammoniacal salts.

510. *What action have the hydrates of sodium and potassium upon the economy?*

They act as powerful corrosives. The symptoms are practically the same as those observed in corrosion by the mineral acids (see Q. 125), except in corrosion by the alkalies a soapy taste, followed almost immediately by a burning sensation, is experienced in place of an acid taste. The reaction of the vomited matters or of the vessel from which the corrosive was taken is the most certain means of diagnosis. The method of death and postmortem appearances, apart from reaction, are the same as in corrosion by the mineral acids. (See Qq. 126, 129.)

511. *What is the action of the carbonates of sodium and potassium on the animal economy?*

The same as that of the hydrates, but much less intense in equal dose. In the case of the potassium salt, the true poisonous action see Q. 513) is usually the more important.

512. *What treatment should be adopted in corrosion by potash or soda?*

The alkali should be neutralized as speedily as possible by the administration of a weak acid, acetic acid in the form of vinegar being the most available. Oils or milk are of service, more as emollients than as true antidotes. The stomach pump is *not* to be used.

513. *How do the salts of potassium differ from those of sodium in their action on the animal economy?*

In any reasonable quantity the sodium compounds are inert beyond the action which they owe to the acid or to their reaction; the potassium salts are possessed of truly poisonous qualities. They cause dyspnœa, diminution of the blood pressure, convulsions, and death from arrest of the heart's action

SILVER.

514. *Give the symbol and atomic weight of silver.*

Its symbol is Ag (Latin, Argentum); its atomic weight 108.

515. *State the principal physical properties of Ag.*

A white metal, capable of a high polish; very malleable and ductile; the best known conductor of heat and electricity; harder than Au, softer than Cu; sp. gr. 10.4–10.5.

516. *Mention some of the chemical properties of silver.*

It is not oxidized in dry or moist air at any temperature; if the air contain traces of sulphuretted hydrogen, the surface of the metal becomes tarnished by the formation of the black silver sulphide. It is attacked at ordinary temperatures by Cl, Br, I, and S. It is not attacked even at high temperatures by the caustic or carbonated alkalies. Silver acts readily upon nitric acid, with formation of silver nitrate.

517. *What is* coin silver?

An alloy of silver and copper.

518. *What is* lunar caustic?

Silver nitrate, $AgNO_3$ = Argenti nitras fusa U. S.; lapis infernalis. It is prepared by dissolving silver in nitric acid, and heating the crystalline residue until it fuses, when it is cast into moulds.

519. *What action has nitrate of silver upon animal tissues?*

In contact with animal matter silver nitrate is rapidly decomposed, metallic silver being deposited and producing the characteristic black stain, while free nitric acid is liberated. It is to the liberation of this substance that lunar caustic owes its action as an escharotic.

520. *Give the analytical characters of the silver salts.*

1. With HCl a white precipitate, insoluble in HNO_3, soluble in ammonium hydrate.

2. With NaHO, or KHO, a brown precipitate, insoluble in excess.

3. With H_2S a black precipitate, insoluble in alkaline sulphides.

AMMONIUM.

521. *What is the ammonium theory?*

The ammoniacal compounds, such as sal ammoniac, are not compounds of ammonia gas, but of a group of atoms (NH_4) called ammonium. This group behaves like an atom of an univalent metal, such as potassium; as potassium chloride has the formula KCl, so ammonium chloride has the formula $(NH_4)Cl$. Liquor ammoniæ is not a simple solution of ammonia gas in water; it contains a true ammonium hydrate $(NH_4)HO$, corresponding in all respects to the hydrates of potassium and sodium, KHO and NaHO, except that upon being heated it is decomposed into ammonia gas and water:

$$\underset{\text{Ammonium hydrate.}}{(NH_4)HO} = \underset{\text{Ammonia.}}{NH_3} + \underset{\text{Water.}}{H_2O}$$

Ammonium has not yet been obtained in a free state with certainty, but an amalgam may be readily obtained, corresponding to the amalgams of sodium and potassium, and containing NH_4Hg.

(See Manual, p. 144.)

522. *What is the present source of the ammoniacal compounds?*

The "ammoniacal liquor" obtained in manufacturing illuminating gas; this is distilled, and the distillate passed into HCl or H_2SO_4, when ammonium chloride or sulphate is formed.

523. *How is ammonium sulphydrate prepared?*

By passing H_2S through a solution of NH_4HO:

$$\left.\begin{matrix}H\\H\end{matrix}\right\}S+\left.\begin{matrix}(NH_4)\\H\end{matrix}\right\}O=\left.\begin{matrix}(NH_4)\\H\end{matrix}\right\}S+\left.\begin{matrix}H\\H\end{matrix}\right\}O.$$

Hydrogen sulphide.	**Ammonium hydrate.**	**Ammonium sulphydrate.**	**Water.**

524. *What are the properties and uses of the solution thus obtained?*

When freshly prepared, it is a colorless liquid, having the odor of ammonia, as well as that of sulphuretted hydrogen; when old it assumes a yellow color. It is a valuable reagent in analysis.

525. *Give the names and formula of ammonium chloride.*

Ammonium chloride, muriate of ammonia, sal ammoniac, ammonii chloridum, U. S.; Br. $(NH_4)Cl$.

526. *What reaction takes place when ammonia gas comes in contact with an acid?*

The two unite to produce an ammonium salt, without liberation of hydrogen, thus:

NH_3	+	HCl	=	$(NH_4)Cl$
Ammonia.		Hydrochloric acid.		Ammonium chloride.

$2NH_3$	+	H_2SO_4	=	$(NH_4)_2SO_4$
Ammonia.		Sulphuric acid.		Ammonium sulphate.

527. *How are the ammoniacal compounds affected by heat?*

They are completely volatilized unless they are salts of a fixed acid.

528. *Give the analytical characters of the ammonium salts.*

1. When heated with KHO they give off NH_3; which may be recognized by its odor, by its turning moist red litmus paper blue, and by the formation of a white cloud when a glass rod moistened with HCl solution is held over the vessel.

2. With platinic chloride, a yellow, crystalline precipitate, converted into a gray, spongy mass when heated.

529. *Wherein does ammonium hydrate differ from the hydrates of potassium and sodium in its action on the economy?*

In the severe dyspnœa which it produces. Owing to the readiness with which NH_3 is given off, the corrosive action of NH_4HO is usually insignificant compared to the action of the NH_3 upon the air passages.

GROUP III. METALS OF THE ALKALINE EARTHS.

CALCIUM	Ca	40
STRONTIUM	Sr	87.5
BARIUM	Ba	137

530. *State the characteristics of elements of this group.*

They are bivalent; they form two oxides having the composition MO and MO_2; their sulphates and carbonates are insoluble; their hydrates are known as the alkaline earths.

CALCIUM.

531. *How does calcium exist in nature?*

In its compounds it is one of the most abundant of the elements. Its carbonate exists as chalk, marble, limestone, etc.; its sulphate as gypsum and alabaster, and several other compounds exist in various minerals. Its compounds also occur in animal and vegetable tissues.

532. *Give the formula and common names of calcic monoxide.*

CaO. Calx, U. S.; Br.; calx viva; quicklime.

533. *State the method of its preparation and its properties.*

It is obtained by heating limestone, which is a native calcic carbonate, when carbonic anhydride is given off, and calcic monoxide remains. It forms white masses, having the shape of the fragments of limestone used, but no crystalline structure. It is odorless; has a caustic, alkaline taste and alkaline reaction. When exposed to the air, it absorbs water and carbonic anhydride, falling to a powder composed of a mixture of calcic carbonate and calcic hydrate; it is then said to be air slaked.

534. *What takes place when calcic oxide is treated with water?*

When H_2O is thrown upon CaO a crackling sound is heard, much heat is liberated, the lime swells up, and a new substance, calcic hydrate, is formed:

$$\underset{\substack{\text{Calcic}\\\text{oxide.}}}{CaO} + \underset{\text{Water.}}{H_2O} = \underset{\substack{\text{Calcic}\\\text{hydrate.}}}{CaH_2O_2}.$$

This is known as slaked lime, and is a light, white powder, odorless, having an alkaline taste and reaction. It is sparingly soluble in cold H_2O, and less soluble in hot H_2O. It absorbs carbonic anhydride readily from the air, forming calcic carbonate.

535. *What are* lime-water *and* milk of lime?

The former is a solution of calcic hydrate in water; the latter is such a solution holding in suspension a great excess of calcic hydrate.

536. *Give the formula and common names of calcium chloride.*

$CaCl_2$. Calcii chloridum, U. S.; Br.; muriate of lime.

537. *How is it obtained, and what are its prominent properties?*

It is formed whenever a calcium compound is acted upon by hydrochloric acid, and notably as a by-product in obtaining carbonic anhydride:

$CaCO_3$	+	$2HCl$	=	$CaCl_2$	+	H_2O	+	CO_2
Marble.		**Hydrochloric acid.**		**Calcium chloride.**		**Water.**		**Carbonic anhydride.**

It is odorless, and has a sharp, salty taste. When fused and allowed to cool, it forms a rough, amorphous mass, which absorbs water with great energy, and is therefore used in the laboratory as a drying agent.

538. *What is the difference between calcium chloride and chloride of lime?*

The former is a definite compound, $CaCl_2$, while the latter is a mixture containing calcium chloride, $CaCl_2$, and calcium hypochlorite, $Ca(ClO)_2$.

539. *Under what other name is chloride of lime known, and what are its properties and uses?*

It is commonly known as bleaching powder. The hypochlorite is very readily decomposed by acids with evolution of chlorine, which then acts as a powerful bleaching and disinfecting agent. When exposed to the air, it is decomposed by the carbonic anhydride contained therein.

540. *What are* gypsum, terra alba, *and* plaster of Paris?

Gypsum is a native calcium sulphate containing two molecules of water of crystallization, $CaSO_4 + 2Aq$. Terra alba is gypsum ground to a fine powder. When gypsum is heated, the Aq. is driven off. The remaining substance, $CaSO_4$, is plaster of Paris, and has the power of taking up water when mixed with it to form a hard, solid mass.

541. *What objection is there to the use of plaster in the ordinary way on walls of hospitals?*

It forms a coating which is porous and uneven. In these pores and upon the projections various deleterious organic substances collect to such an extent that by scratching the surface of plaster in a hospital, a powder has been obtained containing as much as 46 per cent of organic matter.

542. *How may this defect be remedied?*

By adding to the ordinary mixture of plaster and water, used in plastering, a certain proportion of alum and gelatin, or of soluble glass. This mixture, on "setting," forms a hard surface, which is then polished, and may be rendered very smooth; it may also be washed as often as required with water containing a disinfecting agent, such as Liq. sodæ chlorinatæ.

543. *Give the names and formulæ of the phosphates of calcium.*

Monocalcic phosphate, $Ca(H_2PO_4)_2$ = acid calcium phosphate, superphosphate of lime. Dicalcic phosphate, $Ca_2(HPO_4)_2$. Tricalcic phosphate, $Ca_3(PO_4)_2$=Tribasic or neutral phosphate of lime, bone phosphate, calcii phosphas præcipitatus, U. S.; calcii phosphas, Br.

544. *How does $(PO_4)_2Ca_3$ exist in the animal economy?*

It is the most abundant mineral ingredient of the body, and is found in every tissue and fluid, most adundantly in the bones and teeth. In the fluids it exists in small proportion, except in the milk, where it is found in comparatively large quantity (about 2¼ parts per 1,000). In the bones it is in combination with an organic substance, and upon the relative proportions of these two the rigidity and tenacity of the bone depends.

545. *How is "bone black" prepared, and what is its composition?*

It is obtained by subjecting bones to a red heat without access of air. It is composed of carbon, tricalcic phosphate, and small quantities of other salts (calcic carbonate, trimagnesic phosphate, and calcic fluoride). By treating it with dilute hydrochloric acid the mineral substances are removed, and "purified animal charcoal" remains.

546. *How may pure tricalcic phosphate be obtained?*

The impure salt, bone ash, is acted on by HCl when the soluble monocalcic phosphate and calcium chloride are formed:

$$\underset{\text{Tricalcic phosphate.}}{Ca_3(PO_4)_2} + \underset{\text{Hydrochloric acid.}}{4HCl} = \underset{\text{Monocalcic phosphate.}}{Ca(H_2PO_4)_2} + \underset{\text{Calcium chloride.}}{2CaCl_2}$$

Ammonium hydrate is then added to the solution, when pure tricalcic phosphate (calcis phosphas præcipitata, U. S. P.) is precipitated, and ammonium chloride remains in solution:

$$\underset{\text{Monocalcic phosphate.}}{Ca(H_2PO_4)_2} + \underset{\text{Calcium chloride.}}{2CaCl_2} + \underset{\text{Ammonium hydrate.}}{4(NH_4)HO} =$$
$$\underset{\text{Tricalcic phosphate.}}{Ca_3(PO_4)_2} + \underset{\text{Ammonium chloride.}}{4(NH_4)Cl} + \underset{\text{Water.}}{4H_2O}$$

547. *What is "superphosphate of lime?"*

An impure monocalcic phosphate, obtained by acting on bone-ash with sulphuric acid. It is used as a manure.

548. *In what parts of the body does monocalcic phosphate exist?*

In brain-tissue and in the acid fluids; in the urine. This salt and the corresponding magnesium compound are known as "earthy phosphates."

549. *What mineral salts are sometimes deposited from the urine in calculi?*

The earthy phosphates, *i.e.*, tricalcic and trimagnesic phosphates; and ammonio-magnesian phosphate.

550. *What is the reaction of the urine during formation of a phosphatic calculus?*

It is alkaline, or at least markedly less acid than normal.

See Manual p. 149.

551. *In what forms does calcium carbonate occur innature?*

Exceedingly abundant as marble, limestone, chalk and calc spar, and in almost all natural waters and soils, in juices of plants, the shells of mollusks and crustacea, bones, teeth and animal fluids, coral, and pearls.

552. *How is it prepared artificially, and by what name is it then known?*

By adding sodic carbonate to solution of calcium chloride. Calcis carbonas præcipitata, U. S.; Br. Precipitated chalk.

553. *What is* prepared chalk?

It is native chalk ground to a fine powder and separated from all coarser particles by elutriation = Creta preparata, U. S.; Br.

554. *State the properties of calcium carbonate.*

An amorphous white powder, odorless, tasteless, very sparingly soluble in pure water, much more soluble in water containing carbon dioxide. When strongly heated, CO_2 is driven off and quicklime remains.

555. *What does "temporary hardness" in water depend on?*

On the presence of bicarbonates of magnesium and calcium. $Ca(HCO_3)_2$ and $Mg(HCO_3)_2$. When hard water is boiled, CO_2 is driven off and the carbonates are in great part precipitated. Water is also rendered hard by the presence of magnesium and calcium sulphates; this is called permanent hardness, as it is not removed by boiling the water.

556. *What is the appearance of a* mulberry calculus *and of what is it composed?*

It is hard, dark brown or gray, sometimes smooth, usually nodulated or covered with short tubercles, soluble in HCl, and, when heated, blackens and finally leaves a white, alkaline residue. It consist mainly of calcium oxalate CaC_2O_4.

557. *Describe the analytical reactions of the Ca compounds.*

1. With alkaline carbonates, a white precipitate; soluble in HCl.
2. With ammonium oxalate, a white precipitate, soluble in HCl.
3. With H_2SO_4, a white precipitate, either immediately or on addition of two volumes of alcohol.

BARIUM.

558. *What compound of barium is used in analysis, and for what purpose?*

Barium chloride, $BaCl_2$, is used as a test for the presence of sulphuric acid or of a soluble sulphate; a white precipitate of barium sulphate, *insoluble in nitric acid*, is formed.

559. *What antidotes should be given in poisoning by the soluble barium compounds?*

Magnesium or sodium sulphate.

GROUP IV. MAGNESIUM GROUP.

Magnesium	Mg	24
Zinc	Zn	65
Cadmium	Cd	112

560. *Describe the common characters of the elements of this group.*

Each forms a single oxide, and a corresponding basic hydrate. In their salts they are always bivalent.

MAGNESIUM.

561. *Describe the properties of Mg.*

It is a silver white metal, hard, light and ductile. It burns in air with a brilliant white light and with formation of MgO. It dissolves in dilute acids.

562. *Give the formula and common names of magnesium oxide.*

MgO. Magnesia, U. S.; Br. magnesia lævis; magnesia usta; calcined magnesia.

563. *State its properties.*

It is a very light, amorphous, white powder; infusible; very sparingly soluble in water. With HNO_3, H_2SO_4, HCl it forms the corresponding salt. (Effervescence denotes contamination with magnesium carbonate.)

564. *What is "milk of magnesia"?*

Magnesium oxide held in suspension in water (1 part MgO to 10–20 parts H_2O).

565. *Under what other names is magnesium sulphate known and what is its formula?*

Magnesii sulphas, U. S.; magnesiæ sulphas, Br.; sulphate of magnesia; Epsom salts. $MgSO_4$.

566. *Give the characters of $MgSO_4$.*

It forms colorless, transparent crystals, containing 7 molecules of water of crystallization. Easily soluble in water, the solution being neutral. Insoluble in alcohol.

567. *What is* triple phosphate, *how is it formed, and of what pathological interest is it?*

It is ammonio-magnesian phosphate, $(NH_4)MgPO_4 + 6\ Aq$. It is produced whenever a magnesium salt is brought in contact with an alkaline phosphate and an ammonium salt, the reaction being alkaline. In the urine, alkaline phosphates and magnesium salts are always present, hence when ammonia is produced by decomposition of urea, the conditions for the deposition of this compound are fulfilled. Frequently it is deposited in the form of single, brilliant, tabular crystals. In some cases it is slowly deposited, when it forms a "fusible calculus."

568. *How may a magnesium compound be detected in the presence of compounds of barium and calcium?*

The barium and calcium compounds must be first separated thus: add to the solution ammonium chloride and hydrate, then ammonium carbonate; the barium and calcium compounds are precipitated and removed by filtration; to the clear filtrate add solution of sodium phosphate; if magnesium be present, a crystalline precipitate of ammonio-magnesian phosphate is formed.

ZINC.

569. *For what purposes is zinc used?*

In the manufacture of brass, which is an alloy of copper and zinc, and of German silver. "Sheet zinc" is zinc rolled out into thin plates; galvanized iron is sheet iron (or iron wire, etc.) covered with a thin coating of zinc. Galvanized iron and zinc should not be used in vessels intended to contain articles of food, as fatty matter, milk, and even water become rapidly charged with soluble zinc compounds when kept in vessels made of these substances. Zinc is largely used in galvanic batteries, and in the laboratory to obtain hydrogen.

570. *How is commercial zinc nearly always contaminated?*

With arsenic, iron, lead, and phosphorus.

571. *How is zinc oxide obtained?*

1. By subjecting zinc carbonate to heat. The zinci oxidum, U. S.; Br., is thus prepared from the officinal zinc carbonate, which is a mixture of the true carbonate $ZnCO_3$, and the hydrate, ZnO_2H_2. 2. By burning metallic zinc in a current of air. This process is used on a large scale in the arts in the manufacture of "zinc white," which is used as a pigment.

572. *State the differences between samples of zinc oxide prepared by the above processes.*

That prepared by 1 is of a pale yellow color when cold, and yellow when hot, while that prepared by 2 is pure white and forms light flocculent masses, whence it was formerly known as "lana philosophica." That prepared by 1 is liable to contain an excess of carbonate.

572*a*. *State how zinc chloride is obtained, and its properties.*

By dissolving Zn in HCl and evaporating the solution. It is a white solid, crystallizes with difficulty, and is very soluble in water. It combines readily with albuminoid substances. It is used medicinally as an escharotic, and for the preservation of anatomical material.

573. *Describe the action of zinc upon sulphuric acid.*

If both substances be pure, there is no action; but if the acid be diluted with water the zinc is dissolved, zinc sulphate and hydrogen resulting.

Pure Zn acts much less readily on H_2SO_4 than when it is contaminated with other metals. In galvanic batteries, it is desirable that the action between zinc and acid should only take place while the circuit is closed; this end is attained by "amalgamating" the zincs, *i. e.*, coating them with an amalgam of zinc and mercury. Plates so protected behave towards H_2SO_4 like pure zinc.

574. *Why is zinc sulphate incompatible with the vegetable astringents?*

Because they contain tannic acid with which the zinc salt forms an insoluble compound.

575. *Under what other names is zinc sulphate known, and what is its formula?*

White vitriol, zinci sulphas, U. S.; Br. As usually met with its composition is $ZnSO_4+7$ Aq; although it also crystallizes with 1, 2, 4, 5, 6 Aq.

576. *Describe the analytical reactions of the Zn salts.*

1. With ammonium sulphydrate, a white precipitate.

2. With hydrates of K, Na or (NH_4), white precipitates, soluble in excess.

3. With potassium ferrocyanide, a white precipitate.

577. *What preparations of zinc are liable to give rise to cases of poisoning?*

A strong solution of the chloride with excess of acid used by tinsmiths. A disinfecting agent, known as Sir Wm. Burnett's solution, composed of 230 grains $ZnCl_2$ to the ounce of water. Zinc sulphate, taken by mistake.

578. *What should be the treatment?*

If the poison have not produced emesis it should be induced. Milk, white of egg, or better, some substance containing tannic acid, such as tea, infusion of bark, etc., should be given.

GROUP VI. COPPER GROUP.

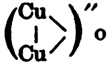
COPPER	Cu	63.5
MERCURY	Hg	200.

579. *What is the valence of elements of this group?*

They are bivalent.

579a. *How many classes of salts do these elements form, and wherein do they differ?*

Two. In one class a single atom of the element acts in its bivalent capacity, Cu'', thus: $Cu''SO_4$; in the other class two atoms of the element, linked together, form a group which behaves likes a single bivalent atom, thus:



or $(Cu_2)''$; $(Cu_2)O$.

580. *Explain the nomenclature of these compounds.*

Those compounds containing the single atom are designated by the termination *ic*, while those containing the double atom $(Cu_2)''$ or $(Hg_2)''$ are designated by the termination *ous*, thus CuO is known as cupr*ic* oxide, and $(Cu_2)O$ as cupr*ous* oxide; $HgCl_2$ as mercur*ic* chloride, and $(Hg_2)Cl_2$ as mercur*ous* chloride. The termination *ous* applies to that compound containing the greater proportion of metal, while the termination *ic* designates that containing the greater proportion of the other element or group of elements; thus we have:

Mercur*ous* chloride, Hg : Cl :: 2 : 2
Mercur*ic* " Hg : Cl :: 1 : 2
Cupr*ous* oxide, Cu : O :: 2 : 1
Cupr*ic* " Cu : O :: 1 : 1

COPPER.

581. *How may pure copper be obtained?*

By decomposing cupric sulphate by means of the battery (electrotype). By heating cupric oxide in a current of hydrogen.

582. *What action takes place between copper and the mineral acids?*

Copper decomposes hydrochloric acid with difficulty, except when the metal is finely divided.

Nitric acid is energetically acted on, nitrogen dioxide being given off and cupric nitrate remaining in solution:

$$\underset{\text{Nitric acid.}}{8HNO_3} + \underset{\text{Copper.}}{3Cu} = \underset{\text{Cupric nitrate.}}{3Cu(NO_3)_2} + \underset{\text{Water.}}{4H_2O} + \underset{\text{Nitrogen dioxide.}}{2NO}$$

Warm sulphuric acid, with copper, forms cupric sulphate, white sulphur dioxide is evolved:

$$2H_2SO_4 + Cu = CuSO_4 + 2H_2O + SO_2$$

Sulphuric acid.	Copper.	Cupric sulphate.	Water.	Sulphur dioxide.

583. *What action takes place between copper and certain organic acids?*

Many weak acids are decomposed with formation of salts of copper; thus, when this metal is exposed to damp air it becomes coated with a green layer of the carbonate. Acetic acid (vinegar), in contact with copper, forms the acetate. The fatty acids also combine with the metal.

584. *Give the names and formulæ of the oxides of copper.*

Cuprous oxide, Cu_2O, also known as red, or suboxide of copper; cupric oxide, CuO, also known as black, or protoxide of copper.

585. *What decomposition takes place when cupric oxide and an organic substance are heated together, and how is this utilized?*

The oxide gives up its oxygen, which, uniting with the carbon and hydrogen of the organic substance, forms carbonic anhydride and water, while metallic copper remains. This reaction affords us one of the best means of analytically determining the quantity of carbon and hydrogen entering into the composition of an organic compound.

586. *What is blue vitriol?*

Cupric sulphate, $CuSO_4$. Cupri sulphas, U. S.; Br.; blue stone.

587. *State its properties.*

Blue crystals with 5Aq; odorless; readily soluble in water, insoluble in alcohol; has a disagreeable, styptic taste. When heated, the Aq is driven off, and a white substance remains, which absorbs water and resumes its blue color with great readiness. Its aqueous solution is acid, and coagulates albumen.

588. *Name some pigments containing Cu used in the arts, and give their composition.*

Scheele's green = mineral green = cupric arsenite. Schweinfurt green = mitis green = Paris green = cupric aceto-metarsenite. Verdigris = basic cupric acetate. Mineral green, azurite or mountain blue, and blue ash = basic cupric carbonates.

589. *Describe the analytical characters of the cupric salts.*

1. With H_2S, a black precipitate, insoluble in NH_4HS, soluble in hot, dilute HNO_3.

2. With KHO or NaHO, pale-blue precipitates, insoluble in excess.

3. With NH_4HO, pale-blue precipitate, forming dark-blue solution in excess.

4. With potassium ferrocyanide, chestnut-brown precipitate, insoluble in weak acids, decolorized by KHO.

5. With bright metallic Fe in presence of an acid reaction, deposition of metallic Cu.

590. *How is copper-poisoning usually occasioned?*

By the ingestion of sulphate or acetate of copper, or, more frequently, by eating food, pickles, etc., which have been cooked or allowed to stand in copper vessels. Occasionally in workers in the metal and by the use of articles of food adulterated with copper compounds.

591. *Does copper exist normally in the body?*

It does not. In analyzing bodies, traces of this metal are always found without any history of its administration; this is, however, not "physiological copper," but has found its way into the economy with the food in small quantities. Copper sulphate is frequently added to flour to render the bread white, and to canned vegetables for the double purpose of "greening" and preserving them.

592. *What peculiarity is noticed in the vomit in copper-poisoning?*

It is blue or green in color. The green color due to copper may readily be distinguished from that produced by bile coloring-matter by the addition of ammonium hydrate, which produces a deep-blue color if copper is present.

593. *What treatment is indicated?*

The administration of albumen (raw white of egg) with which copper salts form an insoluble compound. Emesis or stomach-pump.

594. *Give an easy clinical test for copper.*

Immerse a piece of iron (blade of a knife) into the fluid; if copper be present, it will be deposited in the metallic form; the addition of a little dilute HCl or H_2SO_4 hastens the formation of the deposit.

MERCURY.

595. *Under what other names is this element known?*

Hydrargyrum, U. S.; Br.; mercurius; quicksilver.

596. *Give its symbol, valence, and atomic weight.*

Hg (Latin, Hydrargyrum). It is bivalent. 200.

597. *Of how many atoms is the molecule of mercury composed?*

One.

598. *What is the principal ore of mercury?*

A native sulphide, known as cinnabar.

599. *Give the properties of elementary mercury.*

With the exception of bromine, it is the only element liquid at ordinary temperatures. When cooled to − 40° (− 40° F.) it crystallizes, and when heated to 350° (662° F.) it boils; it is volatile at all temperatures. It has a bright metallic lustre. Pure mercury remains unchanged in air at ordinary temperatures. It unites directly with chlorine, bromine, and iodine.

600. *What is an amalgam?*

An alloy containing mercury.

601. *What important pharmaceutical preparations contain elementary mercury?*

Hydrargyrum cum cretâ, U. S.; Br. = mercury with chalk; Massa hydrargyri, U. S. = Pilulæ hydrargyri, Br. = blue-pill, blue-mass; Unguentum hydrargyri, U. S.; Br. = mercurial ointment.

602. *What is the purpose of the chalk, confection and lard in these preparations?*

To "extinguish" the Hg, *i. e.*, to convert it into exceedingly minute globules which have no tendency to unite.

603. *Has liquid mercury any chemical action on the economy?*

It has not as long as it remains in that form.

604. *How is the mercury in the preparations named absorbed?*

In the manufacture of these preparations a notable quantity of the element is oxidized to mercurous oxide (a greater quantity in blue-pill than in mercury with chalk), this, on contact with the acids of the gastric juice or perspiration, is converted into compounds which are soluble, and therefore capable of absorption.

605. *With what substances is commercial mercury contaminated?*

Lead, tin, bismuth, zinc, and mechanical impurities.

606. *What is meant by mercurous and meric compounds?*

Like copper, mercury forms two series of compounds, in one of which the single bivalent atom Hg enters; these are the mercur*ic* compounds, and contain the least proportionate amount of mercury. In the other, the double atom $(Hg_2)''$ enters as a bivalent group; these are the mercur*ous* compounds.

607. *What is the formula of mercurous oxide?*

Hg_2O.

608. *How is it formed, and what are its properties?*

By digesting mercurous chloride with solution of potassa. It is a black powder, odorless and tasteless; quite unstable; formerly officinal as "black precipitate."

609. *Give the chemical name and formula of the other oxide of mercury.*

Mercuric oxide, HgO.

610. *By what names is it known pharmaceutically?*

Hydrargyri oxidum rubrum, U. S.; Br., hydrargyri oxidum flavum, U. S.; Br., red precipitate, red oxide of mercury.

611. *By what two processes is it prepared?*

1. By heating mercuric nitrate as long as brown fumes are given off, and then washing with alcohol and water. 2. By adding solution of caustic soda to solution of mercuric chloride.

612. *Wherein do oxides prepared by these processes differ from each other?*

The oxide prepared by heat is crystalline, while the precipitated variety forms a yellowish-red, amorphous powder. The latter is much more active in its chemical and therapeutical properties than the former.

613. *Why does the ointment of this substance deteriorate on keeping?*

Because, in contact with fats and certain other organic substances, the oxide is decomposed, the organic matter being oxidized and metallic mercury remaining.

614. *Give the formula and synonyms of mercurous chloride.*

Hg_2Cl_2. Calomel, mild chloride of mercury, Hydrargyri chloridum mite, U. S.; Hydrargyri subchloridum, Br.

615. *Give an account of its preparation.*

Mercuric sulphate is first formed by heating together mercury and sulphuric acid until a dry, white mass remains. This is then mixed with mercury and common salt, and again heated.

$$\underset{\substack{\text{Mercuric}\\\text{sulphate.}}}{HgSO_4} + \underset{\text{Mercury.}}{Hg} + \underset{\substack{\text{Sodium}\\\text{chloride.}}}{2NaCl} = \underset{\substack{\text{Sodic}\\\text{sulphate.}}}{Na_2SO_4} + \underset{\substack{\text{Mercurous}\\\text{chloride.}}}{Hg_2Cl_2}$$

The chloride is volatilized and condensed in the upper part of the vessel, while the sodic sulphate remains. The chloride is then washed with boiling water until the washings no longer form a precipitate with ammonium hydrate.

616. *With what substance is calomel liable to be contaminated?*

With corrosive sublimate.

617. *How may this impurity be detected?*

By placing the powder upon a bright copper surface and moistening with water. If corrosive sublimate be present a silver-white stain is formed on the copper.

618. *Give the properties of mercurous chloride.*

It is a heavy, white, amorphous powder; tasteless, odorless, insoluble in water. It distils without melting. When exposed to light, it is partially decomposed into mercury and corrosive sublimate:

$$\underset{\substack{\text{Mercurous}\\\text{chloride.}}}{Hg_2Cl_2} = \underset{\substack{\text{Mercuric}\\\text{chloride.}}}{HgCl_2} + \underset{\text{Mercury.}}{Hg}$$

This decomposition also takes place when mercurous chloride is boiled for some time with water, and more rapidly in the cold if the water contain alkaline chlorides.

619. *Why are the mineral acids incompatible with calomel?*

Because of their tendency to decompose it, with formation of corrosive sublimate and a soluble salt of mercury with the acid. Nitromuriatic acid produces this decomposition most readily.

620. *Why are the alkaline chlorides, bromides, and iodides incompatible with calomel?*

Because in their presence there is formation of the soluble mercuric chloride, bromide or iodide. It has been found in naval practice that the use of salt provisions precludes the use of calomel.

621. *Why are the caustic and carbonated alkalies incompatible with calomel?*

Because in their presence mercurous oxide is first formed; this is rapidly decomposed into mercuric oxide and mercury, and the former, in the presence of the alkaline chlorides of the gastric juice, is converted into corrosive sublimate.

622. *Give the formula and synonyms of mercuric chloride.*

$HgCl_2$. Hydrargyri chloridum corrosivum, U. S.; hydrargyri perchloridum, Br., perchloride of mercury, bichloride of mercury, corrosive sublimate.

623. *Give the method of its preparation.*

By heating together mercuric sulphate and sodium chloride:

$HgSO_4$ +	$2NaCl$ =	$HgCl_2$ +	Na_2SO_4
Mercuric sulphate.	Sodium chloride.	Mercuric chloride.	Sodic sulphate.

The chloride volatilizes, and is condensed in the upper part of the vessel—sublimes.

624. *State its properties.*

It forms heavy, white, translucent, crystalline masses, or, when pulverized, a pure white powder (calomel has a yellowish tinge), odorless. It has a strong, acrid, styptic taste, and is soluble in 16 parts of cold or in 3 parts of boiling water, also soluble in alcohol and in ether. The aqueous solution is colorless, acid in reaction, and when exposed to light is decomposed, oxygen is given off, hydrochloric acid is formed, and mercurous chloride deposited:

$4HgCl_2$ +	$2H_2O$ =	$2Hg_2Cl_2$ +	$4HCl$ +	O_2
Mercuric chloride.	Water.	Mercurous chloride.	Hydrochloric acid.	Oxygen

The decomposition is accelerated by the presence of organic matter.

625. *What is the action of lime-water upon the chlorides of mercury?*

With mercurous chloride mercurous oxide is formed, and is then decomposed into a mixture of mercuric oxide and mercury: this reaction takes place in the preparation of "black wash." Yellow wash is obtained in a similar manner with mercuric chloride, and holds in suspension a yellow oxychloride.

626. *What reaction takes place between mercuric chloride and ammonium hydrate?*

A white precipitate is formed, which is regarded as ammonium chloride, NH_4Cl, in which two atoms of hydrogen are replaced by one atom of mercury, $NH_2Hg''Cl$. This is the ammoniated mercury or white precipitate of the pharmacopœia.

627. *Give the properties of the compound of mercuric chloride and albumen.*

When mercuric chloride and albumen in solution are brought together a precipitate is formed, which is insoluble in water, but is soluble in an excess of albumen, in dilute hydrochloric acid, or in solutions of alkaline chlorides.

628. *Give the formula and synonyms of mercurous iodide.*

Hg_2I_2. Hydrargyri iodidum viride, U. S.; Br., protiodide, or green iodide of mercury.

629. *State its properties.*

It is a greenish yellow powder, odorless, tasteless, very sparingly soluble in water. It is very readily decomposed into mercuric iodide and mercury.

630. *Give the formula and synonyms of mercuric iodide.*

HgI_2. Hydrargyri iodidum rubrum, U. S.; Br., red iodide, or biniodide of mercury.

631. *State its properties.*

When first formed it is yellow, but rapidly becomes scarlet. It is tasteless, odorless, permanent in air, sparingly soluble in water, but quite soluble in solutions of the chlorides, bromides, or iodides.

632. *What officinal preparation of arsenic contains mercuric iodide?*

Liquor arsenii et hydrargyri iodidi, U. S. P., commonly known as Donovan's solution.

633. *What is vermilion?*

Mercuric sulphide, HgS, prepared artificially.

634. *What is the composition of turpeth mineral?*

It is a basic mercuric sulphate, *i. e.*, mercuric sulphate combined with the oxide: $HgSO_4,2HgO$.

635. *Give the analytical characters of the mercurous salts.*

1. With HCl, a white precipitate, turns black with NH_4HO.
2. With H_2S, a black precipitate, insoluble in NH_4HS, HNO_3 or HCl.
3. With KHO, black precipitate, insoluble in excess.
4. With KI, greenish precipitate.

636. *Give the analytical characters of the mercuric salts.*

1. With H_2S a precipitate, at first white, then orange, finally black.
2. With KHO or NaHO, yellow precipitate.
3. With NH_4HO, white precipitate.
4. With KI, yellow precipitate, rapidly turning salmon colored and red, forming colorless solution with excess of precipitant.
5. With stannous chloride, white precipitate, turning gray and depositing globules of Hg when the liquid is boiled.

637. *How may Hg be best detected in the urine in cases of suspected poisoning?*

By the application of the Reinsch test (see Qq. 328–331).

Or a small bar of Zn, around which a strip of dentists' gold foil has been spirally wound, may be immersed in the urine, acidulated with H_2SO_4. In the presence of Hg the Au is dimmed in 24 hours, and if it be washed, dried and heated in a tube, a sublimate is formed which consists of microscopic globules of Hg.

638. *What kind of mercurials are capable of causing poisoning?*

All soluble compounds, and compounds rendered soluble by contact with digestive liquids.

639. *What compound of Hg is most frequently the cause of poisoning?*

Corrosive sublimate.

640. *Describe the prominent symptoms of acute corrosive sublimate poisoning.*

The nauseous, metallic taste is experienced during the act of swallowing. Within a few moments this is followed by an intense, burning pain in the mouth, throat, and stomach. The mouth and tongue are whitened and shrivelled. There are vomitings of a white material containing shreds of mucous membrane, and tinged with blood, and bloody stools. Salivation occurs if life be sufficiently prolonged. Death sometimes occurs early from collapse, accompanied by convulsions, or in deep coma; but in most fatal cases life is prolonged for from three to six days.

641. *What are the points of diagnosis between arsenical and mercurial poisoning?*

Arsenical Poisoning.	Mercurial Poisoning.
1. The symptoms rarely begin within 20 minutes.	1. The symptoms begin almost immediately.
2. Pain is limited to the stomach.	2. Pain is also severe in the mouth and throat.
3. The taste is sweetish and but faintly metallic.	3. The taste is intensly metallic and nauseous.
4. The mouth and tongue are normal.	4. The mouth and tongue are whitened.
5. The urine contains As.	5. The urine contains Hg.

642. *Give the antidote for corrosive sublimate poisoning.*

White of egg. The following precautions should be observed in its administration: too much should not be given at one time, lest the precipitate be dissolved in the excess; the antidote should be followed by an emetic, to remove the precipitate before it shall have been dissolved by the acid and chlorides of the gastric juice.

643. *Describe the post-mortem appearances in poisoning by* $HgCl_2$.

The salivary glands are enlarged. The tongue, mouth, œsophagus and mucous membrane are usually shrivelled and grayish-white in color, though sometimes they are reddened and intensely inflamed. The intestines are usually highly congested and the urinary bladder contracted and empty.

COMPOUNDS OF CARBON.

644. *Under what other name are these compounds known?*

Organic substances.

645. *What is the distinction between organic and inorganic substances?*

Any compound containing carbon is an organic compound, whether it be a constituent of a vegetable or animal body, or not. The division is simply one of convenience, and is retained owing to the great number of the carbon compounds.

646. *What are the valence, symbol, and atomic weight of carbon?*

It is bivalent and quadrivalent, its symbol is C, and its atomic weight 12.

647. *Of what four elements are organic compounds principally composed?*

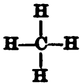
Carbon, hydrogen, oxygen, and nitrogen.

648. *What elements may enter into the composition of organic compounds?*

All the elements.

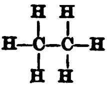
649. *What property do the atoms of carbon possess to an extraordinary degree, and what bearing has this upon organic chemistry?*

The power of combining with each other and interchanging valences, which thus equalize each other and disappear. Were it not for this property of carbon, the number of its compounds would be very much smaller than it is. We could, for example, have but one saturated compound of carbon with hydrogen; $C^{iv}H_4$; we have, however, a large number of such compounds, the constitution of some of which may be thus represented:



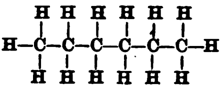
$$\begin{array}{ccc} & H & \\ & | & \\ H- & C & -H \\ & | & \\ & H & \end{array}$$

CH_4



$$\begin{array}{cccc} & H & H & \\ & | & | & \\ H- & C- & C & -H \\ & | & | & \\ & H & H & \end{array}$$

C_2H_6



$$\begin{array}{cccccccc} & H & H & H & H & H & H & \\ & | & | & | & | & | & | & \\ H- & C- & C- & C- & C- & C- & C & -H \\ & | & | & | & | & | & | & \\ & H & H & H & H & H & H & \end{array}$$

C_6H_{14}

650. *What is an homologous series?*

A series of compounds, each term of which differs from the next by CH_2 more or less.

The members of the same series are possessed of similar properties.

651. *What is a general or algebraic formula?*

An algebraic formula applicable to an entire homologous series. Thus the general formula of the series, page 184, is $C_nH_{2n}\ +_2$, and from this formula that of any member of the group may be deduced, if its position in the series be known. If, for example, the formula of the 5th in the series be required $n = 5$, and we have $C_5H(_5 \times {}_2) + {}_2$ or C_5H_{12}.

652. *What are* isomeric *bodies?*

Substances which have the same centesimal composition, but which differ in their properties.

Thus acetic acid and methyl formiate, although entirely distinct substances, endowed with very different properties, consist each of C — 40; O — 53.33; and H —6.67 parts in 100.

653. *How many kinds of isomerism are recognized, and how are they designated?*

Two. Metamerism and Polymerism.

654. *When are two substances said to be metameric?*

When they have the same percentage composition and also the same molecular weight. Thus methyl formiate and acetic acid are metameric because they each have the percentage composition given in Q. 652, and the molecular weight of each is 60.

655. *When are substances said to be polymeric?*

When they have the same percentage composition, but the molecular weight of one is a multiple of the molecular weight of the other. Thus methyl formiate and acetic acid are polymeric with glucose, because each have the percentage composition given in Q. 652; but while the molecular weight of the former two is 60, that of the last is 180, or 60 × 3.

656. *To what are the differences in properties of isomeric substances due?*

To different arrangement of the atoms, different structure of the molecules.

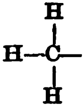
657. *What is understood by the terms composition and constitution?*

The composition of a substance is the number and kind of atoms of which its molecule consists. Its constitution is the intimate structure of the molecule; the arrangement of the atoms with regard to each other.

658. *What is a radical?*

A group of atoms, which is not necessarily capable of isolation, the members of which are so strongly linked together that it is capable of passing unaltered from one compound to another, and in this behaving like an atom.

Example.—Let us consider the compound CH_4 as composed of CH_3H; if we act upon this with iodine we obtain a compound CH_3I; if we now treat this substance, under proper conditions, with potash, we obtain a compound CH_3OH; and, if we act upon this with acetic acid we obtain a compound $CH_3C_2H_3O_2$. This group CH_3 is, therefore, capable of passing from one combination to another without undergoing change itself, it is a radical. As it is composed of one atom of the quadrivalent carbon, three of whose valences are satisfied with atoms of hydrogen, there remains one free valence,



$$\begin{array}{c}H\\|\\H-C-\\|\\H\end{array}$$

, and the radical behaves like an atom of an univalent element $(CH_3)'$.

659. *What are* empirical formulæ?

Formulæ indicating the composition of a substance, but not its constitution. Thus $C_2H_4O_2$ is the empirical formula of both acetic acid and methyl formiate.

660. *What are meant by types?*

Common substances; the arrangement of the atoms in whose molecules may be taken as representative of whole classes of other substances, whose molecules have a similar arrangement.

661. *Under what three types may all organic substances be classified?*

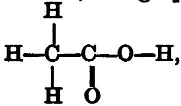
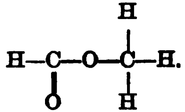
Hydrogen, water, and ammonia. The molecule of hydrogen consists of two atoms united together, thus: $\left.\begin{matrix}H\\H\end{matrix}\right\}$; the molecule of water is composed of two atoms of hydrogen (univalent) united to one atom of oxygen (bivalent), thus: $O\begin{matrix}\diagup H\\ \diagdown H\end{matrix}$, or $\left.\begin{matrix}H\\H\end{matrix}\right\}O$; the molecule of ammonia consists of three atoms of hydrogen united to one atom of nitrogen (trivalent). Under these three types (either singly or combined with each other) all organic substances, whose constitution is known, can be arranged, and we may consider all chemical substances as either hydrogen, water, or ammonia (or a union of two of them) in which one or more of the atoms have been replaced by another atom or a radical, thus:

Hydrogen Type.	Water Type.	Ammonia Type.
$\left.\begin{matrix}H\\H\end{matrix}\right\}$	$\left.\begin{matrix}H\\H\end{matrix}\right\}O''$	$\left.\begin{matrix}H\\H\\H\end{matrix}\right\}N'''$
$\left.\begin{matrix}(CH_3)'\\H\end{matrix}\right\}$	$\left.\begin{matrix}(CH_3)'\\H\end{matrix}\right\}O''$	$\left.\begin{matrix}CHH'\\H'\\ \end{matrix}\right\}N'''$
Marsh gas.	**Wood spirit.**	**Methylamine.**

662. *What are* typical formulæ?

Formulæ partially indicating the constitution of the substance, and constructed by the substitution of a radical or radicals in one of the three types or a combination of two of them. Thus the typical formula of acetic acid is $\left.\begin{matrix}C_2H_3O\\H\end{matrix}\right\}O$, while that of methyl formiate is $\left.\begin{matrix}CHO\\CH_3\end{matrix}\right\}O$.

663. *What is a* graphic formula?

A formula showing the constitution of the substance completely, *i. e.*, the relations of all of the atoms. Thus, the graphic formula of acetic acid is  $H—\overset{H}{\underset{H}{C}}—\underset{O}{C}—O—H$, while that of methyl formiate is  $H—\underset{O}{C}—O—\overset{H}{\underset{H}{C}}—H$. For the sake of brevity these formula are usually written CH_3—CO,OH and H—COO,CH_3. It is obvious that the graphic formula of a substance can only be constructed when its constitution is known.

SATURATED HYDROCARBONS, $C_nH_{2n} + {}_2$.

$\left.\begin{matrix}C\,H_3\\H\end{matrix}\right\}$ Methyl hydride. $\left.\begin{matrix}C_9H_{19}\\H\end{matrix}\right\}$ Nonyl hydride.

$\left.\begin{matrix}C_2H_5\\H\end{matrix}\right\}$	Ethyl hydride.	$\left.\begin{matrix}C_{10}H_{21}\\H\end{matrix}\right\}$	Decyl hydride.
$\left.\begin{matrix}C_3H_7\\H\end{matrix}\right\}$	Propyl “	$\left.\begin{matrix}C_{11}H_{23}\\H\end{matrix}\right\}$	Undecyl “
$\left.\begin{matrix}C_4H_9\\H\end{matrix}\right\}$	Butyl “	$\left.\begin{matrix}C_{12}H_{25}\\H\end{matrix}\right\}$	Bidecyl “
$\left.\begin{matrix}C_5H_{11}\\H\end{matrix}\right\}$	Amyl “	$\left.\begin{matrix}C_{13}H_{27}\\H\end{matrix}\right\}$	Tridecyl “
$\left.\begin{matrix}C_6H_{13}\\H\end{matrix}\right\}$	Hexyl “	$\left.\begin{matrix}C_{14}H_{29}\\H\end{matrix}\right\}$	Tetradecyl “
$\left.\begin{matrix}C_7H_{15}\\H\end{matrix}\right\}$	Heptyl “	$\left.\begin{matrix}C_{15}H_{31}\\H\end{matrix}\right\}$	Pentadecyl “
$\left.\begin{matrix}C_8H_{17}\\H\end{matrix}\right\}$	Octyl “	$\left.\begin{matrix}C_{16}H_{33}\\H\end{matrix}\right\}$	Hexadecyl “

664. *What is a hydrocarbon?*

A compound containing only carbon and hydrogen.

665. *What is a saturated compound?*

One in which all the possible valences of the constituent elements are satisfied, as in $C^{iv}H'_4$.

666. *What name is applied to the members of this series, and why?*

Paraffins, from parum = little, and affinis = affinity; because they are all substances which are decomposed with great difficulty.

667. *What is the composition of the radical methyl?*

CH_3.

668. *Give the formula and synonyms of methyl hydride.*

$\left.\begin{matrix}CH_3\\H\end{matrix}\right\}$. It is also known as Marsh gas, fire damp, light carburetted hydrogen.

669. *Describe its properties.*

It is a colorless, odorless, tasteless gas, lighter than air, sparingly soluble in water; burns with a yellow flame; forms explosive mixtures with air and oxygen. A large quantity of carbon dioxide is formed in an explosion of such a mixture, and is known to miners as "after damp."

670. *What natural product is composed mainly of saturated hydrocarbons?*

Petroleum. [The terms of this series vary regularly as to their boiling point, from the lowest, which is gaseous at ordinary temperatures, to the 16th, which only boils at about 280° (536°F.) A petroleum is liable to explode in proportion as it contains hydrocarbons of low boiling-point.]

671. *Name some of the products obtained from petroleum.*

Petroleum ether or rhigolene, gasolin, benzin, kerosene, lubricating oils, paraffin, vaselin.

672. *What are the properties and uses of petroleum ether?*

It is a colorless liquid, sp. gr. 0.7°, highly inflammable, boils at 21° (70° F.). It is used as a substitute for sulphuric ether to produce cold by its rapid evaporation, and as a solvent.

673. *What are the properties and uses of paraffin?*

It is a white crystalline solid, fusible at 45°–65° (113°–149° F.), used in the manufacture of candles and to protect glass and other surfaces from the action of acids, alkalies, etc.

674. *What is vaselin, and what are its properties and uses?*

It is a mixture of paraffin with lubricating oils. It varies in consistency according to the proportions of the constituents, but has usually the consistency of butter. It is acted upon by chemical agents with great difficulty. It is very extensively used in pharmacy (Petrolatum U. S.) and in perfumery for the purposes formerly served by the animal fats, over which it has the advantage of never becoming rancid.

HALOID DERIVATIVES OF THE PARAFFINS.

675. *What is understood by substitution?*

The replacement of an atom or atoms of one element for an equivalent number of atoms of another element in a compound. Example.—The compound CH_4 being saturated, it is impossible to introduce any other atom into its molecule without, at the same time, displacing therefrom one or more of its atoms. Acting upon CH_4 with chlorine, it is possible to remove each of the atoms of hydrogen and *substitute* therefor atoms of chlorine, forming the substituted compounds CH_3Cl; CH_2Cl_2; $CHCl_3$; CCl_4.

676. *What important substance results from the substitution of three atoms of chlorine for atoms of hydrogen in methyl hydride?*

Chloroform, which is chloride of bichlorinated methyl, $\left.\begin{matrix}CHCl_2\\Cl\end{matrix}\right\}$.

677. *State its physical properties.*

It is a colorless, volatile liquid, having an agreeable ethereal odor and a sweet taste. It is heavier than water, with which it does not mix; it mixes in all proportions with alcohol and ether. It boils at 60°.8 (141°.4 F.) It can only be ignited with difficulty. It is a good solvent for fats, gutta-percha, and many substances rich in carbon.

678. *How is chloroform tested for impurities?*

When used for inhalation it should respond to the following tests: Its sp. gr. should be 1.49. When shaken with an equal volume of colorless H_2SO_4 the mixture should not become hot, and after twenty-four hours the upper $CHCl_3$ layer should be adsolutely colorless, while the acid layer should have only a pale yellow tinge. When thrown upon H_2O it should sink in transparent drops, and the water should not become milky. When evaporated, the last portions should have no pungent odor, and the remaining film of moisture should be tasteless and odorless.

679. *How may $CHCl_3$ be detected?*

With alcoholic solution of KHO and a few drops of aniline it gives off a disagreeable odor resembling that of witch hazel, when heated.

(See Manual, p. 175.)

680. *How are bromoform and iodoform related to chloroform?*

They have the same constitution, bromine or iodine replacing the chlorine,

$\left.\begin{matrix}CHCl_2\\ Cl\end{matrix}\right\}$

Chloroform.

$\left.\begin{matrix}CHBr_2\\ Br\end{matrix}\right\}$

Bromoform.

$\left.\begin{matrix}CHI_2\\ I\end{matrix}\right\}$

Iodoform.

681. *State the principal properties of iodoform.*

It forms yellow crystals, having a strong, disagreeable odor. Insoluble in water, soluble in alcohol. It contains 96 per cent of its weight of iodine.

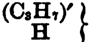
MONOATOMIC ALCOHOLS.

682. *What is an* alcohol?

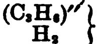
A hydrate containing a hydrocarbon radical, and capable of behaving toward an acid in the same way as the basic hydrate of a metal.

683. *What is meant by the* atomicity *of an alcohol?*

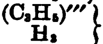
The saturating power of its radical. Thus



$\left.\begin{matrix}(C_3H_7)'\\ H\end{matrix}\right\} O$ is a monoatomic alcohol;

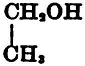
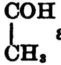
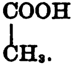


$\left.\begin{matrix}(C_2H_4)''\\ H_2\end{matrix}\right\} O_2$ is a diatomic alcohol, and

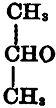
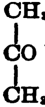


$\left.\begin{matrix}(C_3H_5)'''\\ H_3\end{matrix}\right\} O_3$ is a triatomic alcohol.

684. *What group of atoms is characteristic of* primary *alcohols, and what are their products of oxidation?*

CH_2OH. Their products of oxidation are: first, an aldehyde, and, by more complete oxidation, an acid containing the same number of carbon atoms as the alcohol. Thus the primary alcohol  $\begin{array}{c}CH_2OH\\|\\CH_3\end{array}$ yields by oxidation, first the *aldehyde*  $\begin{array}{c}COH\\|\\CH_3\end{array}$ and then the acid  $\begin{array}{c}COOH\\|\\CH_3\end{array}$.

685. *What group of atoms is characteristic of a* secondary *alcohol, and what is produced from it by oxidation?*

CHOH. A ketone or acetone. Thus the secondary alcohol  $\begin{array}{c}CH_3\\|\\CHOH\\|\\CH_3\end{array}$ produces the ketone  $\begin{array}{c}CH_3\\|\\CO\\|\\CH_3\end{array}$ by oxidation.

685*a*. *What group of atoms is characteristic of a* tertiary *alcohol, and what are its products of oxidation?*

COH. When oxidized, it produces two acids or ketones, each containing a less number of carbon atoms than the original alcohol.

686. *Give the empirical, typical, and graphic formulæ, and the names of methyl hydrate.*

CH_4O; $\left.\begin{matrix}CH_3\\H\end{matrix}\right\}O$; $\begin{array}{c}CH_2OH.\\|\\H\end{array}$ Methylic alcohol, wood alcohol, pyroxylic spirit, carbinol.

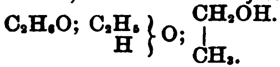
687. *How is methyl alcohol obtained commercially?*

By the distillation of wood.

688. *What is methylated spirit?*

Spirits of wine containing ten per cent of wood spirit. This does not interfere with its use in the arts, but communicates a disagreeable taste and odor which prevent its being taken internally.

689. *Give the empirical, typical, and graphic formulæ, and the names of ethyl hydrate.*



C_2H_6O; $\left.\begin{matrix}C_2H_5\\H\end{matrix}\right\}O$; $\begin{matrix}CH_2OH.\\|\\CH_3.\end{matrix}$ Ethylic alcohol, vinic alcohol, alcohol, spirits of wine, methyl carbinol.

690. *From what substance is alcohol usually obtained?*

From starch.

691. *Describe briefly the method of obtaining alcohol from starch.*

The process is divisible into three parts: 1. The grain is *malted, i. e.*, it is caused to germinate. In this stage of the process, a peculiar substance, called *diastase*, is produced, which causes the transformation of starch into glucose. 2. The saccharine liquid is brought in contact with *yeast*, a plant whose nutrition is attended with *fermentation*, by which glucose is decomposed into alcohol and carbon dioxide: $C_6H_{12}O_6 = 2C_2H_6O + 2CO_2$. 3. The alcohol is more or less perfectly separated from other substances by distillation.

692. *Explain the difference between the various kinds of ethyl alcohol used in the arts and in pharmacy.*

They differ from each other mainly in the proportion of alcohol and water.

Absolute alcohol—is pure alcohol, C_2H_6O. [It is only obtained with difficulty, and deteriorates rapidly, owing to its great tendency to absorb water. The so-called absolute alcohol of the shops is seldom stronger than 98 per cent.]

Alcohol U. S.—Stronger alcohol. Has a specific gravity of 0.820, and contains 94 per cent alcohol. [Manufacturing apparatus has been so perfected that alcohol of this strength may be obtained by a single distillation.] Spiritus rectificatus, Br., sp. gr. 0.838 contains 84 per cent of alcohol.

Alcohol dilutum, U. S. = *Spiritus tenuior, Br.*, is of sp. gr. 0.920, and contains 53 per cent alcohol.

Proof spirit—Spirits of wine—contains 49 per cent alcohol.

693. *State the principal properties of alcohol.*

It is a colorless, mobile fluid, having, when pure, sp. gr. 0.794, and boiling point, 78° (172°.5 F.). It has a peculiar odor and a sharp, burning taste; very volatile. It has a great attraction for water, and to this are due its coagulating action on albumin and its preservative action on animal substances. It is a very useful solvent.

694. *What is the alcoholic strength of "spirituous liquors?"*

From 53 to 56 per cent alcohol.

695. *Mention the sources of some of the principal spirits.*

Brandy (spir. vini Gallici, U. S.; Br.) is obtained by subjecting wine to distillation. Rum, by fermenting and distilling molasses. American whiskey, *Spiritus frumenti U. S.*, from rye, wheat, or Indian corn. Irish whiskey, from potatoes; and Scotch whiskey, from barley. [The peculiar smoky flavor is produced by drying the grain over a peat fire.] Gin is obtained from various grains, and is flavored with juniper berries.

696. *Wherein do wines differ from spirits?*

In that they contain a smaller proportion of alcohol, and, as they are not subjected to distillation, in containing a variety of solid substances present in the juice of the grape, which do not exist in spirits.

697. *What is the alcoholic strength of "light" wines?*

From 7 to 10 per cent.

698. *Of heavy wines?*

From 14 to 17 per cent.

699. *What is the alcoholic strength of malt liquors?*

From 1½ to 9 per cent.

700. *Describe the various products of the oxidation of alcohol.*

These vary according as the oxidation is rapid or slow. If the oxidizing agent be energetic, as chromic anhydride, the alcohol burns, and is converted into carbon dioxide and water:

$$\underset{\text{Alcohol.}}{C_2H_6O} + \underset{\text{Oxygen.}}{3O_2} = \underset{\substack{\text{Carbon}\\\text{dioxide.}}}{2CO_2} + \underset{\text{Water.}}{3H_2O}$$

If the oxidation take place more slowly, it is limited to the substitution of an atom of oxygen for two of hydrogen in the radical, forming acetic acid:

$$C_2H_6O + O_2 = C_2H_4O_2 + H_2O$$

Alcohol. Oxygen. Acetic acid. Water.

If the action take place still more slowly, aldehyde is formed:

$$2C_2H_6O + O_2 = 2C_2H_4O + 2H_2O$$

Alcohol. Oxygen. Aldehyde. Water.

For tests for alcohol, see Manual, p. 183.

701. *Give the formula and synonyms of amyl hydrate.*

$\left.\begin{matrix}C_5H_{11}\\H\end{matrix}\right\}O$. Amyl alcohol, fusel oil, grain oil, potato spirit.

702. *What practical interest attaches to it?*

It is produced in small quantities along with varying quantities of propyl, butyl, and hexyl alcohols, in alcoholic fermentation, and, as it has deleterious properties, must be carefully separated from the spirits. The separation is, however, never complete, nor should it be, as the substances to which a properly aged spirit owes its flavor are formed by the gradual oxidation of these alcohols.

SIMPLE ETHERS.

703. *What substance is formed by substituting for the remaining extraradical hydrogen of alcohol the radical ethyl?*

Oxide of ethyl, or ethylic ether, $\left.\begin{array}{l}(C_2H_5)'\\(C_2H_5)'\end{array}\right\}O = C_4H_{10}O$, commonly known as "sulphuric ether."

704. *What are* simple, mixed, *and* compound ethers?

Simple and mixed ethers are oxides of the alcoholic radicals, the radicals being the same in the simple ethers and different in the mixed ethers. Compound ethers are acids in which the hydrogen has been replaced by hydrocarbon radicals. Thus $\left.\begin{array}{c}CH_3\\CH_3\end{array}\right\}O$ is a simple ether, $\left.\begin{array}{c}CH_3\\C_2H_5\end{array}\right\}O$, a mixed ether, and $\left.\begin{array}{c}C_2H_3O\\CH_3\end{array}\right\}O$ a compound ether.

705. *Why is the name "sulphuric ether" improper as applied to ethyl oxide?*

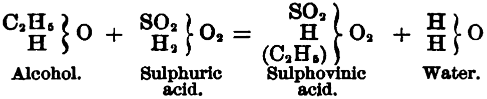
Because it contains no sulphur; the name properly applies to another substance, $\left[\left.\begin{array}{c}SO_2\\(C_2H_5)_2\end{array}\right\}O_2\right]$ It should be called ethylic ether.

706. *Describe the manufacture of ether.*

A mixture of H_2SO_4 and alcohol is maintained at a temperature of 140° (284° F.) in a retort into which flows a slow but constant stream of alcohol, and which is connected with a suitable condenser. The first distillation yields a mixture of $C_4H_{10}O$, C_2H_6O, and small quantities of H_2SO_4. To purify the ether, this mixture is shaken with milk of lime and H_2O. Upon standing, the ether, purified from H_2SO_4 and C_2H_6O rises to the surface, and is decanted. This product is known as "washed ether," and still contains H_2O, which can only be removed by the addition of calcium oxide and redistillation. As thus purified, it forms the Æther fortior, U. S.; Æther purus, Br.

707. *Explain the conversion of alcohol into ether.*

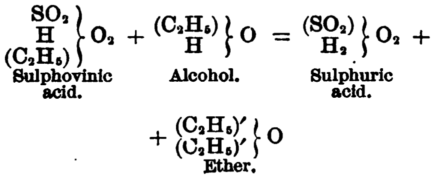
A small quantity of H_2SO_4 is capable of etherifying a large quantity of C_2H_6O. This was one of the processes formerly explained (?) by the empty word "catalysis." One molecule of H_2SO_4 and one of C_2H_6O first act upon each other, the ethyl of the C_2H_6O replacing an atom of hydrogen of the acid with formation of a substance called sulphovinic acid:



$$\left.\begin{matrix}C_2H_5\\H\end{matrix}\right\}O + \left.\begin{matrix}SO_2\\H_2\end{matrix}\right\}O_2 = \left.\begin{matrix}SO_2\\H\\(C_2H_5)\end{matrix}\right\}O_2 + \left.\begin{matrix}H\\H\end{matrix}\right\}O$$

Alcohol. Sulphuric acid. Sulphovinic acid. Water.

As soon as the sulphovinic acid is formed it reacts molecule for molecule with alcohol, giving up again the radical ethyl, which replaces the extraradical hydrogen of the alcohol, while H_2SO_4 is regenerated:



$$\left.\begin{matrix}SO_2\\H\\(C_2H_5)\end{matrix}\right\}O_2 + \left.\begin{matrix}(C_2H_5)\\H\end{matrix}\right\}O = \left.\begin{matrix}(SO_2)\\H_2\end{matrix}\right\}O_2 + \left.\begin{matrix}(C_2H_5)'\\(C_2H_5)'\end{matrix}\right\}O$$

Sulphovinic acid. Alcohol. Sulphuric acid. Ether.

708. *State the properties of ethylic ether.*

It is a colorless, mobile liquid, having a peculiar and tenacious odor; it is lighter than H_2O, in which it is only slightly soluble. It boils at 35° (95° F.) at ordinary barometric pressure, and is very volatile at all temperatures. It is highly inflammable, and its vapor forms an explosive mixture with air. It is an excellent solvent of fats, resins, alkaloids, etc.

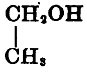
709. *What precautions are to be observed to guard against ignition of ether?*

That it be used at a distance from lights and fires. The vapor of ether is heavier than air, and more danger is therefore to be apprehended from a grate fire than from a chandelier. In administering ether at night, the light should be held well above the patient.

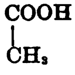
MONOBASIC ACIDS. $C_nH_{2n}O_2$.

710. *Explain the formation of the monobasic acids from the corresponding alcohols.*

They are produced by the substitution of an atom of oxygen for H_2 in the group CH_2OH of the primary alcohol. Thus the graphic formulæ of ethylic alcohol and acetic acid are:

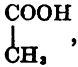
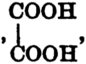


$$\begin{array}{c} CH_2OH \\ | \\ CH_3 \end{array}$$



$$\begin{array}{c} COOH \\ | \\ CH_3 \end{array}$$

711. *What group of atoms is characteristic of organic oxyacids?*

COOH. The basicity of the acid depends upon the number of such groups which it contains. Thus acetic acid,  $\begin{array}{l} COOH \\ | \\ CH_3 \end{array}$, is monobasic; oxalic acid,  $\begin{array}{l} COOH \\ | \\ COOH \end{array}$, is dibasic, etc.

712. *Under what other name is the series of monobasic acids known and why?*

The volatile fatty acids. So called because the lower members are volatile liquids, while the higher terms are important constituents of the animal fats.

713. *What acid of this series is obtained from ethylic alcohol?*

Acetic acid = Acetyl hydrate $\left.\begin{matrix} C_2H_3O \\ H \end{matrix}\right\} O$ = Acidum aceticum, U. S.; Br.

714. *How is the pure acid designated, and what are its properties?*

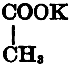
Glacial acetic acid; Acidum aceticum glaciale, U. S.; Br. A colorless liquid, which solidifies to an ice-like mass at 17° (62°.6 F.), and boils at 119° (246°.2 F.). It has a pungent odor and a pure acid taste and acid reaction. It attracts moisture from the air, and should be kept in well-closed bottles. The commercial acid usually contains about 35 per cent $C_2H_4O_2$.

715. *What is the composition of vinegar, and how is it obtained?*

It is dilute acetic acid, holding in solution the soluble constituents of the liquid from which it is obtained. It is prepared by the oxidation of some substance containing alcohol, as wine, cider, infusion of malt, as a result of the processes of nutrition of an organized ferment, known as *mother of vinegar* or *mycoderma aceti.*

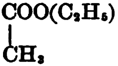
716. *What are the salts and ethers of acetic acid called, and what is their constitution?*

Acetates. Acetic acid contains in each molecule one atom of hydrogen capable of being replaced by a metal. The acetates of the univalent metals and radicals, therefore, have the constitution:



$$\begin{array}{l}\mathrm{COOK}\\ |\\ \mathrm{CH_3}\end{array}$$

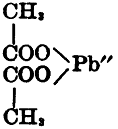
Potassium acetate.



$$\begin{array}{l}\mathrm{COO(C_2H_5)}\\ |\\ \mathrm{CH_3}\end{array}$$

Ethyl acetate.

while those of the bivalent metals are formed by one atom of the metal replacing the hydrogen of two molecules of acid:



$$\begin{array}{l}\mathrm{CH_3}\\ |\\ \left.\begin{array}{l}\mathrm{COO}\\ \mathrm{COO}\end{array}\right>\mathrm{Pb}''\\ |\\ \mathrm{CH_3}\end{array} \quad \text{or} \quad \mathrm{Pb(C_2H_3O_2)_2}$$

Lead acetate.

717. *Where does butyric acid occur in nature?*

In milk and butter principally; also in the perspiration, muscular fluid, contents of the intestine, and in the products of putrefaction.

718. *Explain the formation of free butyric acid in the intestine.*

It is partially formed by the decomposition of butyrates contained in certain fats, but the greater quantity has its source from the saccharine elements of food, which are, to a certain extent, first converted into lactic acid, and this into butyric acid.

719. *Give the formula, occurrence, and method of artificial preparation of valerianic acid.*

$\left.\begin{matrix}C_5H_9O\\H\end{matrix}\right\}O$. It occurs in valerian root, but is more easily obtained by the oxidation of amylic alcohol:

$$\left.\begin{matrix}C_5H_{11}\\H\end{matrix}\right\}O + O_2 = \left.\begin{matrix}C_2H_9O\\H\end{matrix}\right\}O + H_2O$$

Amyl hydrate.	Oxygen.	Valerianic acid.	Water.

720. *What valerianates are officinal?*

Those of sodium, ammonium, zinc, and quinine.

721. *What other acids of this series occur in combination in the animal economy?*

Caproic, $C_5H_{11}COOH$; caprylic, C_7H_{15},COOH; capric, C_9H_{19},COOH; myristic, $C_{13}H_{27}COOH$; palmitic, $C_{15}H_3$,COOH; and stearic, $C_{17}H_{35}$-COOH.

COMPOUND ETHERS.

722. *What is a compound ether?*

A substance resembling a salt, the difference being that the hydrogen of the acid is replaced by a hydrocarbon radical in place of by a metal. The alcohols behave towards the acids in a manner precisely like the metallic hydrates:

$$\left.\begin{matrix}NO_2\\H\end{matrix}\right\}O+\left.\begin{matrix}K\\H\end{matrix}\right\}O=\left.\begin{matrix}NO_2\\K\end{matrix}\right\}O+\left.\begin{matrix}H\\H\end{matrix}\right\}O$$

Nitric acid. Potassium hydrate. Potassium nitrate. Water.

$$\left.\begin{matrix}NO_2\\H\end{matrix}\right\}O+\left.\begin{matrix}(C_2H_5)\\H\end{matrix}\right\}O=\left.\begin{matrix}NO_2\\C_2H_5\end{matrix}\right\}O+\left.\begin{matrix}H\\H\end{matrix}\right\}O$$

Nitric acid. Alcohol. Ethyl nitrate or nitric ether. Water.

723. *What is the formula of nitrous ether, and in what officinal preparation does it exist?*

$\left.\begin{matrix}NO\\(C_2H_5)\end{matrix}\right\}O.$ Spiritus ætheris nitrosi, U. S.; Br.: sweet spirits of nitre is a solution of this substance in alcohol.

724. *What is the composition of the true sulphuric ether?*

$\left.\begin{matrix}SO_2\\(C_2H_5)_2\end{matrix}\right\}O_2$ = ethyl sulphate.

725. *Name some of the compound ethers used in medicine, and give their formulæ.*

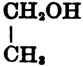
Ethyl acetate = Æther aceticus, U. S.; $\left.\begin{matrix}C_2H_3O_2\\(C_2H_5)\end{matrix}\right\}O.$ Amyl nitrite=amyl nitris, U S.; $\left.\begin{matrix}NO\\(C_5H_{11})\end{matrix}\right\}O.$ Spermaceti = cetaceum, U. S.; Br., consists essentially of cetyl palmitate, $\left.\begin{matrix}C_{16}H_{31}O\\C_{16}H_{33}\end{matrix}\right\}O.$

ALDEHYDES.

726. *What are* aldehydes?

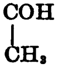
They are substances produced from alcohols by a degree of oxidation limited to the removal of hydrogen, without introduction of oxygen. The name is a corruption of *alcoholum dehydrogenatum.*

727. *Explain by graphic formulæ the relations of the aldehydes to the alcohols and acids.*



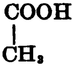
$$\begin{array}{l} CH_2OH \\ | \\ CH_3 \end{array}$$

Ethyl alcohol.



$$\begin{array}{l} COH \\ | \\ CH_3 \end{array}$$

Acetic aldehyde.



$$\begin{array}{l} COOH \\ | \\ CH_3 \end{array}$$

Acetic acid.

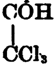
It appears from these formulæ that the aldehydes are intermediate between the alcohols and the acids, into the former of which they are readily converted by the introduction of H_2, and into the latter by oxidation.

728. *Describe the properties of acetic aldehyde.*

It is a colorless, mobile liquid, having a strong suffocating odor; boils at 21° (69°.8 F.); soluble in all proportions in water, alcohol, and ether. Taken internally it produces rapid and deep intoxication. It is readily converted into a polymere, *paraldehyde,* $C_6H_{12}O_3$, a substance liquid above 10°.5 (50°.9 F.), but crystalline below that temperature.

729. *Explain the relation between chloral and aldehyde.*

Chloral is aldehyde in which H_3 has been replaced by Cl_3, therefore *trichloraldehyde*



$$\begin{array}{l} COH \\ | \\ CCl_3 \end{array}$$

730. *Describe the properties of chloral.*

A colorless, oily liquid, having a penetrating odor and an acrid, caustic taste; sp. gr. 1.5; boils at 94°.4 (201°.9 F.), very soluble in water, alcohol, and ether. With a small quantity of water, chloral combines to form a crystalline hydrate CCl_3COH,H_2O which is the *chloral U. S.;* improperly so called.

731. *What reaction takes place between chloral or its hydrate and the alkalies?*

When the two are brought together the mixture becomes milky, and after a time separates into two layers, the lower of chloroform, and the upper a solution of potassium formiate:

$$\underset{\text{Chloral.}}{C_2HCl_3O} + \underset{\text{Potassium hydrate.}}{KHO} = \underset{\text{Chloroform.}}{CHCl_3} + \underset{\text{Potassium formiate.}}{CHO_2K}$$

732. *Describe the prominent symptoms of acute chloral poisoning.*

Deep sleep, with the vessels of the head and neck greatly congested, accelerated pulse, widely dilated pupils, and deep though irregular respiration. Later the face becomes blanched and livid, the pupils contracted, the circulation and respiration fail, and the temperature falls. In some cases death occurs in from one-quarter to one hour in a condition of collapse. The usual fatal period is 8–10 hours.

733. *What treatment is indicated in acute chloral poisoning?*

Stomach pump. Artificial respiration, flagellation, faradism (strychnine cautiously ?).

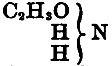
AMINES AND AMIDES.

734. *What are* amines *and* amides*?*

Substances derivable from ammonia by substitution of hydrocarbon, or of oxidized radicals for a portion or all of the hydrogen. If the substituted radicals be hydrocarbon the substance is an *amine*, if oxidized an *amide*:

$$\left.\begin{matrix} CH_3 \\ H \\ H \end{matrix}\right\} N$$

Methylamine.



$$\left.\begin{matrix} C_2H_3O \\ H \\ H \end{matrix}\right\} N$$

Acetamide.

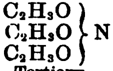
If the substitution occur in a single molecule of ammonia and the radical or radicals be univalent, the substance is a *monamine* or *monamide*. If it contain a single substituted radical, it is a *primary* monamine or monamide; if two, *secondary*, and if three, *tertiary*:

$$\left.\begin{matrix} CH_3 \\ H \\ H \end{matrix}\right\} N$$

Primary monamine; Methylamine.

$$\left.\begin{matrix} CH_3 \\ CH_3 \\ H \end{matrix}\right\} N$$

Secondary monamine; Dimethylamine.



$$\left.\begin{matrix} C_2H_3O \\ C_2H_3O \\ C_2H_3O \end{matrix}\right\} N$$

Tertiary monamide; Triacetamide.

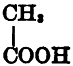
The amines are also known as *compound ammonias*, as they are substances capable of behaving toward acids, in the same way as ammonia, to form hydrates and salts:

H_4N, OH	$(CH_3)_4N, OH$
Ammonium hydrate.	Tetramethylammonium hydrate.
H_4N, Cl	$(CH_3)_4N, Cl$
Ammonium chloride.	Tetramethylammonium chloride.

AMIDO ACIDS.

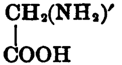
735. *What are* amido acids?

They are substances, partly acid and partly basic in function, produced from the acids by the substitution of the group (NH_2) for an atom of H in the radical. Thus:



$$\begin{array}{l} CH_3 \\ | \\ COOH \end{array}$$

Acetic acid.



$$\begin{array}{l} CH_2(NH_2)' \\ | \\ COOH \end{array}$$

Amidoacetic acid.

735a. *Under what other names is amidoacetic acid known?*

Glycin, glycocol, glycocine, gelatin sugar.

736. *How does it occur in the body?*

It is not found in the economy as such, but enters into the composition of a peculiar acid, which is found as its sodium salt in the bile, and is known as glycocholic acid.

737. *What other peculiar acid is found in human bile?*

Taurocholic acid; also in the form of its sodium salts.

738. *Describe Pettenkofer's reaction for the biliary acids.*

The fluid (urine, etc.) is evaporated to dryness at 100° (212° F.); the residue is extracted with strong alcohol, and the extract mixed with ten volumes of ether. The precipitate formed is collected upon a filter, and, after having been washed with ether, is dissolved in a small quantity of water. To this aqueous solution a drop or two of a solution of cane sugar (1-4) and then strong H_2SO_4 are added. The addition of the acid must be so conducted that the temperature of the mixture does not rise above 70° (158° F.). If the bile salts be present, a turbidity usually appears at first, and then a fine purple color, more or less intense according to the quantity of biliary salt present.

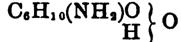
739. *To what substance is this reaction due?*

Cholic acid, formed by the decomposition of the tauro or glycocholate.

740. *Why can the method given in* 738 *not be simplified?*

Because the same reaction occurs with numerous other substances—as albumin, fibrin, oleic acid and the oleates, amylic alcohol, the salts of morphine and codeine, etc. The object of the first part of the process, as given in 738, is to separate any of these substances that may be present.

741. *Under what other name is amidocaproic acid known, and what is its constitution?*

Leucin. 

$$\left.\begin{matrix} C_6H_{10}(NH_2)O \\ H \end{matrix}\right\} O$$

742. *Where does it occur, and how is it formed?*

It exists in most glandular organs. It has not been detected in the blood or urine in health, but appears in the latter fluid in yellow atrophy of the liver. It results from the decomposition of albuminoid substances by the action of strong alkalies or acids, and during putrefaction. In the body it is formed during the processes of nutrition, and is subjected to further change. It is not eliminated in health.

ACRYLIC SERIES OF ACIDS.

743. *How do acids of this series differ from those of the acetic series in composition?*

They contain two atoms of hydrogen less, their general formula being $C_nH_{2n-2}O_2$.

744. *What two acids of this series are of medical interest?*

745. Crotonic acid, $C_4H_6O_2$, and oleic acid, $C_{18}H_{34}O_2$.

745*a*. *Mention the points of interest of crotonic acid.*

It exists in combination with glycerin as an ether in croton oil. The aldehyde corresponding to this acid, C_4H_6O, furnishes a chlorinated derivative similar to chloral, a hydrate of which is used medicinally under the name croton chloral hydrate.

746. *In what form does oleic acid exist in nature?*

In combination with glycerin it forms the greater part of all the oils, animal and vegetable.

747. *What are its properties?*

A colorless or slightly yellow, oily fluid, neutral in reaction when pure. Upon exposure to air it becomes yellow, rancid, and acid. At

14° (57°. 2 F.), it solidifies to a crystalline mass. Almost insoluble in water, soluble in alcohol and ether.

748. *In what officinal preparation is allyl sulphocyanate contained, and what are the properties of that substance?*

In the essential oil of mustard = oleum sinapis volatile, U. S. The sulphocyanate, to which the rubefacient and vesicant actions of mustard are due, is produced by the action of a nitrogenized substance, called *myrosine*, upon *potassium myronate*, contained in the mustard, in the presence of H_2O at a moderate temperature. Myrosine is coagulated and rendered inert by a temperature of 40° (104° F.) or by contact with acetic acid.

HYDROCARBONS. C_nH_{2n}.

749. *Which is the most important member of the second series of hydrocarbons?*

Ethylen, C_2H_4; also known as olefiant gas, elayl, or heavy carburetted hydrogen.

750. *Of what industrial product is it the most important constituent?*

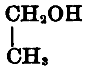
Illuminating gas.

751. *State its properties.*

It is a colorless gas, having a peculiar, disagreeable odor; it burns with a luminous flame and forms explosive mixtures with air and oxygen. It is irrespirable. Equal volumes of this gas and chlorine unite directly to form an oily liquid having the composition $C_2H_4Cl_2$, known as "Dutch liquid."

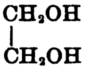
752. *What series of alcohols correspond to these hydrocarbons? Explain their constitution.*

The glycols. The primary alcohols of the ethylic series are monoatomic (see Qq. 683, 684), and contain a single group CH_2OH. The glycols are diatomic and contain two such groups:



$$\begin{array}{c} CH_2OH \\ | \\ CH_3 \end{array}$$

Monoatomic primary alcohol.



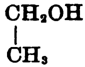
$$\begin{array}{c} CH_2OH \\ | \\ CH_2OH \end{array}$$

Diatomic primary alcohol.

ACIDS $C_nH_{2n}O_3$ AND $C_nH_{2n-2}O_4$.

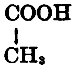
753. *Explain the relations between the primary glycols and the acids derived from them by oxidation.*

The primary, monoatomic alcohols, containing a single group CH_2OH (see Qq. 683, 684, 710), yield by oxidation each a single acid:



$$\begin{array}{c} CH_2OH \\ | \\ CH_3 \end{array}$$

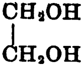
Ethylic alcohol.



$$\begin{array}{c} COOH \\ | \\ CH_3 \end{array}$$

Acetic acid.

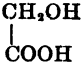
The glycols, containing two groups CH_2OH, produce two series of acids by oxidation, each of which is diatomic, as the alcohol is diatomic, but one is monobasic, containing a single group COOH, while the other is dibasic, containing two such groups;



$$\begin{array}{l}CH_2OH\\ |\\ CH_2OH\end{array}$$

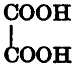
Diatomic
alcohol.

Glycol.



$$\begin{array}{l}CH_2OH\\ |\\ COOH\end{array}$$

Diatomic
monobasic
acid.
Glycolic acid.



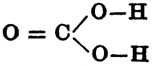
$$\begin{array}{l}COOH\\ |\\ COOH\end{array}$$

Diatomic
dibasic
acid.
Oxalic acid.

ACIDS. SERIES $C_nH_{2n}O_3$, $\left.\begin{array}{r}C_nH_{2n-2}O\\ H_2\end{array}\right\}O_2$

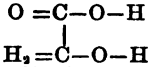
754. *How does the first term of this series differ from the remainder in basicity?*

The first acid of the series is dibasic, while the remainder are monobasic. The extended graphic formulæ indicate the cause of this difference:



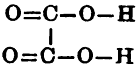
$$O = C\begin{array}{l}\diagup O-H\\ \diagdown O-H\end{array}$$

Carbonic acid.
Dibasic.



$$\begin{array}{l}O=C-O-H\\ \quad\;\; |\\ H_2=C-O-H\end{array}$$

Glycollic acid.
Monobasic.



$$\begin{array}{l}O=C-O-H\\ \quad\;\; |\\ O=C-O-H\end{array}$$

Oxalic acid.
Dibasic.

755. *Does carbonic acid exist free in nature?*

It does not; the substance usually designated by this name is the corresponding anhydride.

756. *What compounds of carbon and oxygen exist free?*

Carbon monoxide CO = Carbonic oxide.
" dioxide CO_2 = " anhydride.

757. *Under what conditions is carbon monoxide formed?*

When coal is burnt with an insufficient supply of air; in open charcoal fires; by passing

CO_2 or steam over red-hot coal; by heating oxalic acid with H_2SO_4.

758. *Describe the prominent properties of CO.*

It is a colorless, odorless, tasteless gas, lighter than air, very sparingly soluble in H_2O. It unites readily with O to form CO_2, burns in air with a blue flame, and reduces metallic oxides at high temperatures.

759. *What is the action of CO on the animal economy?*

It is actively poisonous. It causes death from deprivation of oxygen, by forming a compound with hæmoglobin, which is more stable than the oxygen compound, and whose formation consequently interferes with the oxygen-carrying function of the blood pigment.

760. *What industrial gases contain CO?*

The gases discharged from blast furnaces and from copper furnaces (13 to 32%); the gases emanating from charcoal fires; the gases produced during the combustion of anthracite coal with deficient draught; coal gas (4 to 7.5%); "water gas" (30 to 35%).

761. *What treatment should be followed in asphyxia by CO, and what is the prognosis?*

Stimulants and plenty of fresh air may prevent cessation of respiration, but it is questionable whether they or artificial respiration are of much value after the breathing has stopped. In that case, transfusion of blood is strongly indicated. The prognosis is very unfavorable.

762. *What is the appearance of the blood after death from CO?*

It is persistently bright-red in color. When examined spectroscopically, it shows two absorption bands of equal intensity, and nearer to the violet end of the spectrum than those of oxyhæmoglobin. A solution of NaHO (sp. gr. 1.3) added to normal blood produces a black precipitate, which is greenish-brown in thin layers. With carbon monoxide blood, the same reagent forms a bright-red clot.

763. *Under what names is CO_2 known?*

Carbon dioxide, carbonic anhydride, and, improperly, carbonic acid.

764. *How is CO_2 produced?*

By the combustion or complete oxidation of carbon or of any substance containing carbon; by the decomposition of a carbonate by a stronger acid; by the respiration of animals; by fermentation. Carbon dioxide is also discharged into the atmosphere by volcanoes, or fissures in the earth in volcanic regions; from mineral springs; from lime kilns, cement works, etc.; and from mines by explosions of fire-damp.

765. *Give the main physical properties of CO_2.*

Under ordinary conditions of pressure and temperature, a colorless, odorless gas, having a faint acid taste; under the influence of increased pressure and diminished temperature, it forms a liquid which is very volatile, and which solidifies at −90° (−130° F.). Gaseous CO_2 will neither burn nor support combustion. It is soluble in water, the quantity dissolved increasing with the pressure.

766. *In what proportion does CO_2 exist in air?*

About 4 in 10,000.

See Manual, pp. 235-243.

767. *Why does it not accumulate in the air?*

Because it is absorbed by plants under the influence of sunlight, and is by them decomposed, the carbon entering into the various organic substances produced by the plant.

768. *What action has pure CO_2 when inhaled?*

It produces spasm of the glottis and almost immediate death.

769. *In what two ways may the proportion of CO_2 in air be increased?*

1. By the addition of CO_2 to normal air, as in the processes of fermentation and lime burning. 2. By the oxidation in air of a substance containing carbon, as in the processes of combustion and respiration.

770. *Which of these most rapidly renders air unfit for respiration, and why?*

The second; because not only is the deleterious gas increased, but it is formed at the expense of the oxygen, which is correspondingly diminished.

771. *How does air coming from the lungs differ from inspired air?*

The proportion of O is diminished, while that of CO_2 and H_2O is increased.

772. *What proportion of CO_2 is contained in expired air?*

About 4 per cent in volume.

773. *What proportion of oxygen is absorbed from the air in passing through the lungs?*

About 5 per cent in volume.

774. *How do candles and gas lights compare with human beings in the quantity of oxygen which they consume, and of carbon dioxide which they produce?*

A candle about equals an adult man in the quantity of O consumed, and of CO_2 produced in its combustion. An ordinary gas-burner is equal to ten adults.

775. *What is "soda water?"*

Water holding in solution a large quantity of CO_2 under pressure. The gas escapes in bubbles when the pressure is removed.

776. *How is carbon dioxide obtained?*

By decomposing a carbonate by an acid:

$$Na_2CO_3 + 2HCl = 2NaCl + H_2O + CO_2$$

Na_2CO_3	$2HCl$	$2NaCl$	H_2O	CO_2
Sodic carbonate.	Hydrochloric acid.	Sodium chloride.	Water.	Carbon dioxide.

777. *By what tests is it recognized?*

By the formation of a white precipitate when it is bubbled through lime-water. By being absorbed when confined over a solution of potassium hydrate.

778. *Explain the constitution of the carbonates.*

Although free carbonic acid $\left.\begin{matrix}(CO)''\\H_2\end{matrix}\right\}O_2$ does not exist, the corresponding salts are widely diffused in nature. As the acid is dibasic, the univalent metals form with it two series of salts, in one of which only one atom of hydrogen is replaced by a metal, and in the other both:

$$\left.\begin{matrix}(CO)''\\ H\\ Na'\end{matrix}\right\}_2O \qquad \left.\begin{matrix}(CO)''\\ Na_2\end{matrix}\right\}O_2$$

With bivalent metals, two salts also exist, each containing a single atom of the metal, in the one case substituted in a single molecule of the acid, in the other in a double molecule.

779. *What compound of carbon and sulphur resembles carbon dioxide in its constitution?*

Carbon disulphide CS_2, or sulphocarbonic anhydride.

780. *What are its properties?*

Clear, colorless liquid, refracting light strongly, having a disagreeable, penetrating odor, and sharp taste; heavier than H_2O, with which it does not mix; volatile at ordinary temperatures, boils at 42° (107°.6 F.); has not been solidified; burns readily, forms an explosive mixture with air; good solvent for fats, resins, and india-rubber.

781. *How is "ordinary lactic acid" formed, and under what other names is it known?*

By a peculiar fermentation, known as the lactic, of sugars, in sour milk, and in a variety of other fermented products, as in sauerkraut and some kinds of pickles. It also exists in the stomach during digestion of vegetable food, but is not a constituent of the gastric secretion. It is also called lactic acid of fermentation; acidum lacticum, U. S.

782. *State its characters.*

It is a clear, sirupy liquid, having a slight, not unpleasant odor and a sour taste; it is heavier than H_2O, with which it mixes in all proportions, as well as with C_2H_6O and $C_4H_{10}O$. It is a strong monobasic acid, although it contains two extraradical atoms of hydrogen.

783. *Where does sarcolactic acid occur?*

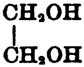
In the juices of muscular tissue, bile, and in the urine in phosphorus poisoning.

ACIDS. SERIES $C_nH_{2n-2}O_4$.

$$\left.\begin{array}{r} C_nH_{2n-4}O_2 \\ H_2 \end{array}\right\} O_2$$

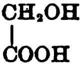
784. *State the basicity of the acids of the series $C_nH_{2n-2}O_4$, and explain their relation to the series $C_nH_{2n}O_3$ and to the glycols.*

They are dibasic. They are the products of oxidation of the glycols, more complete than in the case of the series $C_nH_{2n}O_3$.



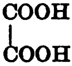
$$\begin{array}{l} CH_2OH \\ | \\ CH_2OH \end{array}$$

Glycol.



$$\begin{array}{l} CH_2OH \\ | \\ COOH \end{array}$$

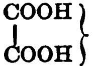
Glycollic acid.



$$\begin{array}{l} COOH \\ | \\ COOH \end{array}$$

Oxalic acid.

785. *What is the composition of oxalic acid, and how does it occur in nature?*



$$\left.\begin{array}{l} COOH \\ | \\ COOH \end{array}\right\} = C_2O_4H_2.$$

It exists, in combination with K, Na, and Ca, in many vegetables, to which it gives a sour taste: sorrel, pie-plant, etc.

786. *How is it prepared industrially?*

By the oxidation of starch, sugar, wood, or other organic matter, by KHO, or by HNO_3.

787. *Describe its properties.*

Crystallizes in colorless, odorless prisms, with 2Aq; has a sour taste; soluble in 8 parts cold, and much more soluble in hot water, as well as in alcohol and ether. It is a strong dibasic acid; its solutions have a strong acid reaction and act as corrosives upon animal tissues. Poisonous.

788. *In mistake for what substance is oxalic acid sometimes taken?*

Epsom salt.

789. *Describe the symptoms of oxalic acid poisoning.*

They vary much in character according to the amount and degree of concentration of the dose. With large doses in concentrated solution, the corrosive action of the acid is the more prominent, with smaller amounts its truly poisonous effects are more apparent.

The sour taste of the acid is rapidly followed by a burning pain, increasing in intensity, in the mouth, throat, and stomach; and persistent vomiting of a dark, "coffee-ground" material. The pulse becomes small and imperceptible, and the patient dies in collapse, preceded frequently by convulsions, within half an hour.

If the case be prolonged, swallowing becomes very difficult and painful; there are numbness and tingling of the skin; twitchings of the facial muscles; convulsions, frequently tetanic; delirium; and lumbar pain.

Death occurs in some cases within three

to ten minutes, sometimes almost immediately, and in some cases it is delayed for several days.

790. *What treatment should be followed in cases of oxalic acid poisoning?*

Magnesia (magnesia usta), or slaked lime suspended in a small quantity of water, or mucilaginous liquid, should be given *as soon as possible.* If vomiting do not occur, and if the symptoms of corrosion be not marked, an emetic. The stomach pump should *not* be used, nor should the alkaline carbonates be depended upon as antidotes.

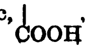
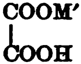
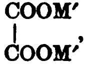
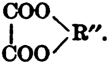
791. *What action has oxalic acid upon cloth and writing ink?*

It forms a brown stain upon cloth, and bleaches writing ink. Writing removed by oxalic acid may be restored in blue by moistening with solution of potassium ferrocyanide.

792. *Give tests for oxalic acid and the soluble oxalates.*

Calcium chloride added to the solution, neutralized with NH_4HO, forms a white, crystalline precipitate, which is insoluble in acetic acid, but soluble in HCl. The same precipitate is formed with lime-water, or solution of calcium sulphate. Silver nitrate, in neutral solution, forms a white precipitate, which is easily soluble in HNO_3. This precipitate does not darken when the fluid is boiled, but when dried and heated it explodes.

793. *Explain the constitution of the oxalates.*

Oxalic acid being dibasic,  $\begin{array}{c}\mathrm{COOH}\\ | \\ \mathrm{COOH}\end{array}$, forms with the univalent metals two series of salts,  $\begin{matrix}COOM'\\ |\\ COOH\end{matrix}$ and  $\begin{matrix}COOM'\\ |\\ COOM'\end{matrix}$, and with the bivalent metals a single series,  $\left.\begin{matrix}COO\\ |\\ COO\end{matrix}\right>R''$.

DIAMIDES.

794. *Explain the constitution of the diamides and of the imides.*

The diamides are substances derived from a double molecule of ammonia by the substitution of one or more bivalent oxidized radicals for one or more pairs of hydrogen atoms. The imides are derived from a single molecule of ammonia by the substitution of a bivalent oxidized radical for two of its hydrogen atoms:

$\left.\begin{matrix}H_2\\H_2\\H_2\end{matrix}\right\}N_2$	$\left.\begin{matrix}(CO)''\\H_2\\H_2\end{matrix}\right\}N_2$	$\left.\begin{matrix}H\\H\\H\end{matrix}\right\}N$	$\left.\begin{matrix}CO\\H\end{matrix}\right\}N$
Ammonia; double molecule.	Carbamide; diamide	Ammonia; single molecule.	Carbamide; imide.

795. *Under what names is the amide of carbonic acid known, and what is its constitution?*

Carbamide, Urea. $\left.\begin{matrix}(CO)''\\H_4\end{matrix}\right\}N_2$

796. *Give the principal physical properties of urea.*

Crystallizes in transparent needles or four-sided prisms, without Aq; permanent in air; odorless, having a cooling, slightly bitter taste, resembling that of saltpetre. Soluble in an equal weight of cold water, very soluble in boiling water, and in five parts of cold or one part of hot alcohol, the solutions being neutral in reaction. At 120° (248° F.) it melts, and slightly above that temperature is decomposed.

797. *In what animal fluids is urea found?*

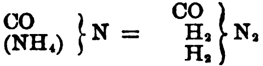
In the blood, lymph, humors of the eye, perspiration, and especially in the urine.

798. *What is the source of urea in economy?*

It is the principal product of the oxidation of albuminoid substances in the animal body, and is the form in which most of the nitrogen is excreted.

799. *How may urea be obtained synthetically?*

By heating its isomere, ammonium cyanate:



$$\left.\begin{array}{l}CO\\(NH_4)\end{array}\right\}N = \left.\begin{array}{c}CO\\H_2\\H_2\end{array}\right\}N_2$$

Ammonium cyanate. Urea.

800. *What occurs when an aqueous solution of urea is long heated?*

Urea takes up the elements of two molecules of water, and is converted into ammonic carbonate:

$$CON_2H_4 + 2H_2O = (NH_4)_2CO_3$$

Urea. Water. Ammonic carbonate.

801. *Under what other conditions does this change occur?*

Under the influence of certain ferments, and of decomposing animal matter. When urea is heated with a base, or with an acid. When a base is used ammonia is liberated, and a carbonate formed:

$$\underset{\text{Urea.}}{CON_2H_4} + \underset{\substack{\text{Potassium}\\\text{hydrate.}}}{2KHO} = \underset{\text{Ammonia.}}{2NH_3} + \underset{\substack{\text{Potassium}\\\text{carbonate.}}}{K_2CO_3}$$

When an acid is used, carbon dioxide is given off and an ammoniacal salt remains:

$$\underset{\text{Urea.}}{CON_2H_4} + \underset{\substack{\text{Sulphuric}\\\text{acid.}}}{H_2SO_4} + \underset{\text{Water.}}{H_2O} = \underset{\substack{\text{Ammonic}\\\text{sulphate.}}}{(NH_4)_2SO_4} + \underset{\substack{\text{Carbon}\\\text{dioxide.}}}{CO_2}$$

802. *What effect have chlorine, bromine, and nitrous acid upon urea?*

Chlorine and bromine, and the hypochlorites and hypobromites decompose urea with formation of hydrochloric or hydrobromic acid, carbon dioxide, and nitrogen:

$$\underset{\text{Urea.}}{CON_2H_4} + \underset{\text{Water.}}{H_2O} + \underset{\text{Chlorine.}}{3Cl_2} = \underset{\substack{\text{Hydro-}\\\text{chloric}\\\text{acid.}}}{6HCl} + \underset{\substack{\text{Carbon}\\\text{dioxide.}}}{CO_2} + \underset{\substack{\text{Nitro-}\\\text{gen.}}}{N_2}$$

Nitrous acid (or nitric acid charged with the oxides of nitrogen) produces an oxidation of urea:

$$\underset{\text{Urea.}}{2CON_2H_4} + \underset{\text{Oxygen.}}{3O_2} = \underset{\text{Water.}}{4H_2O} + \underset{\substack{\text{Carbon}\\\text{dioxide,}}}{2CO_2} + \underset{\text{Nitrogen.}}{2N_2}$$

803. *What occurs when pure nitric or oxalic acid is added to a cold concentrated solution of urea?*

The nitrate or oxalate of urea is formed, and, as these are much less soluble than urea, they separate as crystals.

804. *What quantity of urea is discharged by a normal adult in 24 hours?*

From 25 to 35 grams. (About 1 to 1½ ℥).

805. *How does the elimination of urea vary with age and sex?*

Taking the quantity excreted in 24 hours by an average adult man at 0.5 grm. for each kilogram of body weight, it is found that in children the elimination is much greater. A child of 6 years discharges in 24 hours 1 grm. urea for each kilo. of body weight. In old persons the elimination of urea diminishes. Females discharge less urea than males, except during pregnancy, when the elimination is much increased.

806. *How does the diet affect the elimination of urea?*

The more highly nitrogenized the diet the greater the elimination of urea.

807. *Give a clinical method for determining whether the elimination of urea is excessive or deficient.*

Take from the fresh, mixed urine of 24 hours two samples, one of 5 cc. and the other of double that quantity, and place them in watch glasses. To the smaller sample add about one-third of its volume of pure *colorless* HNO_3; if crystals appear in this immediately or within a few moments the amount of urea is above the normal. Evaporate the other sample to one-half its bulk at a low temperature (over a water-bath or on the corner of a stove where the temperature does not exceed 90°) (194° F.), allow it to cool and add HNO_3 as before; if crystals do not form within a few moments the proportion of urea is below the normal.

The quantity of urine passed in 24 hours must be taken into consideration; thus, if instead of the normal quantity of 1,200 cc., the patient only pass 600 cc., the first sample should be diluted with its own volume of H_2O, and the second used without evaporation; if, on the other hand, the urine be that of a diabetic patient, passing 3,600 cc. per diem, 15 cc. of the urine reduced to 5 by evaporation should be used for the first test, and 30 cc. reduced to 5 for the second.

For a more accurate method, see Manual, p. 257.

808. *To what pathological causes may diminution or increase of elimination of urea be due?*

A diminution may be due to some condition interfering with the normal transformation of albuminous substances in the body, as in certain chronic diseases. More frequently, however, a diminished proportion of urea in the urine is not due to a diminution in the production, but to the fact that the urea formed has not been separated by the kidneys, as in uræmia, and in diseases attended with dropsical effusions. An excess of urea occurs in fevers and in true diabetes, in which it indicates the amount of waste of tissue, and is, therefore, a grave symptom.

URIC ACID AND ITS DERIVATIVES.

809. *Give the formula of uric acid.*

$C_5H_4N_4O_3$. Its constitution is as yet unknown.

810. *In what parts of the body does it occur?*

In the urine of the carnivora and in the excrements of birds, reptiles, and insects; in the blood, spleen, lungs, liver, pancreas and brain. It enters into the composition of many urinary calculi, and the so-called "chalk stones" deposited in the joints in gout.

811. *In what form does it exist?*

It does not occur uncombined in the normal body, but exists as the urates of sodium and ammonium; principally the former.

812. *What is the source of uric acid in the economy?*

It is a product of the oxidation of albuminous substances, and is one of the intermediate steps in the formation of urea.

813. *Give the properties of pure uric acid.*

A light, white powder, composed of small crystals; odorless, tasteless, very sparingly soluble in H_2O, insoluble in alcohol and ether, soluble without decomposition in H_2SO_4 or HCl. Moist uric acid has an acid reaction. It is a dibasic acid.

814. *Give a test for the presence of uric acid.*

Moisten with HNO_3 and evaporate nearly to dryness, cool, add NH_4HO. If uric acid be present, the HNO_3 residue is yellow or red, and on addition of the NH_4HO a brilliant red color is produced.

815. *What substance is formed in this reaction?*

Murexid.

816. *How may uric acid be obtained from urine?*

By adding HCl, and allowing the mixture to stand. The HCl unites with the base, and the uric acid thus liberated, being insoluble, is deposited.

817. *How do the crystals obtained by* 816 *differ from those of pure uric acid?*

In being yellow or brown. The coloring matter of the urine adheres tenaciously to uric acid, and it is very difficult to obtain the pure acid from this source. The form of the crystal also differs from that of crystals of the pure acid.

818. *What is the object of administering lithium compounds in diseases attended with excessive production of uric acid?*

Urate of lithium is more soluble than urate of sodium; therefore, if the former salt be formed in the body in place of the latter, there is less danger of the formation of deposits. If deposits already exist, either in the tissues or as calculi, their solution and removal is aided by the formation of lithium urate.

819. *How much uric acid is normally excreted in 24 hours?*

From 0.3 to 0.8 gram (4.6 to 12.3 grains).

820. *Give a process for the quantitative determination of uric acid in urine,*

Place 200 c.c. of urine in a beaker, add 5 c.c. pure HCl; stir, cover, and set aside for 24 hours; collect the crystals formed upon a small weighed filter, wash with cold distilled water until the washings no longer precipitate with silver nitrate; dry the filter with the adhering crystals and weigh; the difference between this weight and that of the filter gives the amount of uric acid. A slight correction is required for the sparing solubility of uric acid. If the amount of wash water used do not exceed 30 c.c., no correction is required; if it do, add to the result 0.045 milligr. for each c.c. more than 30 used.

821. *What reaction of the urine favors the deposition of uric acid gravel or calculi?*

A strongly acid reaction.

822. *Where does xanthin occur?*

In the urine and muscular tissue; as the main constituent of certain rare urinary calculi.

823. *What substance, closely related to xanthin, is found in muscular tissue?*

Hypoxanthin or sarkin.

824. *Mention the points of interest connected with kreatin and kreatinin.*

The former is found in voluntary and involuntary muscular tissue. It is more abundant in that of animals that have been hunted than in those that have died quietly. It is a product of disassimilation of the albuminous constituents of muscle. Kreatin occasionally appears in the urine in small quantities, but is usually converted into kreatinin, which is a constant constituent of the urine.

TRIATOMIC ALCOHOLS.

825. *What important triatomic alcohol is known? Explain its constitution.*

Glycerin; $C_3H_8O_3$. A monoatomic alcohol may be regarded as a molecule of water, in which one atom of hydrogen is replaced by an univalent radical: $\left.\begin{matrix}(C_2H_5)'\\ H\end{matrix}\right\}O$; a diatomic alcohol as a double molecule of water, in which a double atom of hydrogen has been replaced by a bivalent radical: $\left.\begin{matrix}(C_2H_4)''\\ H_2\end{matrix}\right\}O$; and a triatomic alcohol as a triple molecule of water, in which a triple atom of hydrogen has been replaced by a trivalent radical: $\left.\begin{matrix}(C_3H_5)'''\\ H_3\end{matrix}\right\}O_3$ = glycerin.

The intimate structure of the molecules is shown by the graphic formulæ:

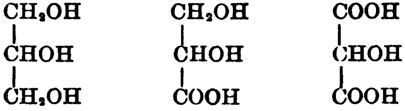
$$\begin{array}{ccc} CH_2OH & CH_2OH & CH_2OH \\ | & | & | \\ CH_3 & CH_2OH & CHOH \\ & & | \\ & & CH_2OH \end{array}$$

Ethylic alcohol. Monoatomic.	Glycol. Diatomic.	Glycerin. Triatomic.

826. *Give the physical characters of glycerin.*

A colorless, odorless, sirupy liquid; neutral in reaction; miscible in all proportions with water; having a sweetish taste; not altered by exposure to air.

827. *Write the graphic formula of glycerin and those of the acids obtainable from it by oxidation.*



$$\begin{array}{ccc} CH_2OH & CH_2OH & COOH \\ | & | & | \\ CHOH & CHOH & CHOH \\ | & | & | \\ CH_2OH & COOH & COOH \end{array}$$

Glycerin. Glyceric acid. Tartronic acid.

828. *Where does malic acid occur in nature?*

It occurs either free or in combination with K, Na, Ca, or Mg in many fruits, such as apples, cherries, the berries of the mountain ash, etc.

829. *Into what salts are the malates, citrates and tartrates converted in the economy, and with what influence upon the urine?*

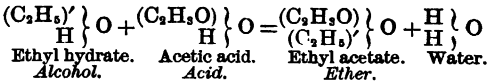
They are oxidized with formation of the corresponding carbonates. As these salts are alkaline in reaction, they diminish the acidity of the urine or render it alkaline.

830. *What are the* glycerides?

They are compound ethers produced by the action between glycerin and the acids. As glycerin is triatomic, it behaves like the hydrate of a trivalent metal and consequently forms three ethers with the monobasic acids:

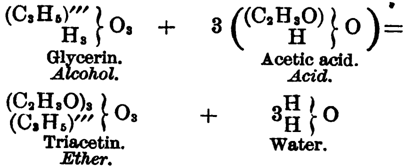
$$\left.\begin{matrix}K\\H\end{matrix}\right\}O + \left.\begin{matrix}(C_2H_3O)\\H\end{matrix}\right\}O = \left.\begin{matrix}(C_2H_3O)\\K\end{matrix}\right\}O + \left.\begin{matrix}H\\H\end{matrix}\right\}O$$

Potassium hydrate.	Acetic acid.	Potassium acetate.	Water.
Base.	*Acid.*	*Salt.*	



$$\left.\begin{matrix}(C_2H_5)'\\H\end{matrix}\right\}O+\left.\begin{matrix}(C_2H_3O)\\H\end{matrix}\right\}O=\left.\begin{matrix}(C_2H_3O)\\(C_2H_5)'\end{matrix}\right\}O+\left.\begin{matrix}H\\H\end{matrix}\right\}O$$

Ethyl hydrate. Acetic acid. Ethyl acetate. Water.
Alcohol. *Acid.* *Ether.*



$$\left.\begin{matrix}(C_3H_5)'''\\H_3\end{matrix}\right\}O_3+3\left(\left.\begin{matrix}(C_2H_3O)\\H\end{matrix}\right\}O\right)=$$

Glycerin. Acetic acid.
Alcohol. *Acid.*

$$\left.\begin{matrix}(C_2H_3O)_3\\(C_3H_5)'''\end{matrix}\right\}O_3+3\left.\begin{matrix}H\\H\end{matrix}\right\}O$$

Triacetin. Water.
Ether.

Similarly we have *diacetin* $(C_2H_3O_2)_2(C_3H_5)HO$, and *monacetin*, $(C_2H_3O_2)(C_3H_5)(HO)_2$.

831. *What important vegetable and animal substances consist of glycerides?*

The fixed oils and fats.

832. *What is the chemical difference between the* fixed *and* volatile *oils?*

The fixed oils are glycerides, constituted as already described and capable of saponification. The volatile oils are for the most part hydrocarbons, and are not subject to the same decompositions as the glycerides.

833. *What are the principal glycerides occurring in the fixed oils and fats?*

Tristearin, tripalmitin, and triolein.

834. *How do these three differ in their physical properties?*

Tristearin and tripalmitin are solid at the ordinary temperature, the former fusing at 68° (154°. 4 F.), the latter at 50° (122° F.). Triolein is liquid at the ordinary temperature and only solidifies at 0° (32° F.).

835. *To what conditions is the difference in consistency of the fixed oils and fats due?*

Partly to the temperature, all fats becoming liquid when heated, and the oils solidify when cooled sufficiently. At a given temperature the consistency depends upon the relative proportions of triolein on the one hand, and tripalmitin and tristearin on the other.

836. *What glyceride of a mineral acid is used in the arts, and for what purpose?*

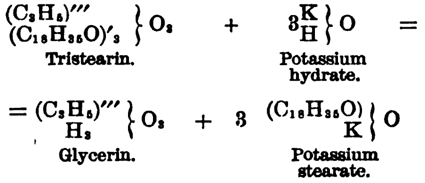
Trinitroglycerin. As an explosive, either alone, or mixed with some inert substance as in dynamite, giant powder, etc.

837. *What is an emulsion?*

A liquid fat in a state of fine and permanent subdivision and suspension in a watery fluid. Oil and water will not mix under ordinary conditions; but if small quantities of certain other substances, such as albumin, be added, and the two liquids shaken together, an emulsion is formed.

838. *Explain the process of saponification.*

It is a double decomposition between a fat and an alkali, in which the metallic salt of the acid and glycerin are formed:



$$\left.\begin{matrix}(C_3H_5)'''\\(C_{18}H_{35}O)'_3\end{matrix}\right\}O_3 + 3\left.\begin{matrix}K\\H\end{matrix}\right\}O =$$

Tristearin. Potassium hydrate.

$$= \left.\begin{matrix}(C_3H_5)'''\\H_3\end{matrix}\right\}O_3 + 3\left.\begin{matrix}(C_{18}H_{35}O)\\K\end{matrix}\right\}O$$

Glycerin. Potassium stearate.

839. *What is the source of the fats in the body?*

They are, to a great extent, taken with the food in their own form, but are also formed in the body from starchy and saccharine substances, and even from albuminous substances. Animals may be fattened on food which contains little fat, but is rich in starch.

840. *What changes do fats undergo in the economy?*

They are oxidized, and their component elements are finally discharged as CO_2 and H_2O. It is highly probable that this oxidation is not direct, but that certain substances are formed during the process, intermediate between the fats and the final products. This oxidation in the body is attended by the liberation of force and heat; a fatty diet is, therefore, eminently suited to cold climates, as it maintains the body temperature in two ways: 1st, by the liberation of heat in its oxidation; and 2d, by preventing the loss of heat, the layer of fat between the skin and the tissues acting as a non-conductor.

841. *State the prominent physical properties of fats.*

They are lighter than water, with which they do not mix. When liquid fats are shaken with water they form globules of varying size, circular in outline, and refract light strongly. They are soluble in ether, to a certain extent in alcohol, and in solutions of the alkalies with formation of soaps. They produce a translucent stain on paper.

842. *What is a soap, and what is the chemical difference between hard and soft soap?*

A mixture of the stearate, palmitate, and oleate of Na or K. The Na compounds form the hard soaps, and the K compounds soft soap.

843. *In what respect does butter fat differ from other fats and oils?*

In containing a notable proportion (5 to 8 per cent) of the glycerides of butyric acid and its near homologues. These acids themselves differ from stearic, palmitic, and oleic acid in being soluble in water and capable of being distilled, while the higher acids are insoluble and are decomposed when heated.

844. *In what situations in the body do the* lecithins *occur?*

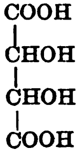
In nerve and brain tissue, particularly the gray substance, blood-corpuscles, blood serum, milk, bile, and seminal fluid.

845. *What substances are derived from lecithin by decomposition by a base?*

Glycerophosphoric acid, stearic acid, and choline.

TARTARIC ACID.

846. *What is the constitution and basicity of tartaric acid?*



$$\begin{array}{l} COOH \\ | \\ CHOH \\ | \\ CHOH \\ | \\ COOH \end{array} = C_4H_6O_6.$$

It is dibasic, only the

two hydrogen atoms contained in the groups COOH being replaceable.

847. *State the properties of tartaric acid.*

Crystallizes in large, hard, transparent prisms; odorless; having a sour, but not disagreeable taste. Very soluble in water; soluble in alcohol. The aqueous solution becomes mouldy on standing.

848. *Give the composition of seidlitz powders, and explain the reaction which occurs when their solutions are mixed.*

The powder in the blue paper is a mixture of Rochelle salt (q. v.) and hydro-sodic carbonate; the white paper contains tartaric acid. When the solutions are mixed, the carbonate is decomposed by the acid; sodic tartrate remains in the solution, while the liberated CO_2 produces the effervescence.

849. *Give an account of the source of tartaric acid and the tartrates.*

The tartrates exist in the juice of the grape in notable quantities, and are obtained industrially as a by-product in the manufacture of wine. During the fermentation of wine, the must becomes more and more alcoholic, and the hydro-potassic tartrate which it contains, being less soluble in alcoholic fluids than in water, is gradually deposited, forming the crude tartar, or "argol" of commerce.

850. *What are the chemical name and characters of cream of tartar?*

Hydro-potassic tartrate, obtained by purifying crude tartar. A white crystalline powder, odorless, having a sourish taste; soluble in 480 parts of cold and in 20 parts of hot water; insoluble in alcohol.

851. *How is Potassæ tartras, U. S. P., formed, and what is its chemical name?*

By adding hydro-potassic tartrate to solution of potassic carbonate, when CO_2 is liberated and potassic tartrate, $C_4H_4O_6K_2$, is formed.

852. *In what important physical character does it differ from hydro-potassic tartrate, and how?*

It is very soluble in water, while the hydro-salt is only sparingly soluble. It has hence received the common name of soluble tartar.

853. *What is the composition of Rochelle salt?*

It is double tartrate of potassium and sodium: $COONa - (CHOH)_2 - COOK = C_4O_6H_4NaK$.

854. *What is the composition of tartar emetic?*

It is a double tartrate of potassium and the radical $(SbO)'$: $COOK-(CHOH)_2-COO(SbO) = C_4O_6H_4K(SbO)$ or antimonyl-potassic tartrate.

855. *State its properties.*

It forms shining, colorless, transparent prisms with 1 Aq, or a white powder; odorless; having a sweetish, unpleasant, metallic taste; soluble in 15 parts cold or 2 parts hot water.

856. *Whence is citric acid obtained, and what are its characters?*

From lemon juice. It forms large, colorless crystals, with 1 Aq, having a strong acid taste; very soluble in water, the solution becoming mouldy by keeping. It is tribasic acid.

FOURTH SERIES OF HYDROCARBONS.

857. *How is oil of turpentine obtained?*

A resinous juice, exuded from incisions in certain varieties of pine, and known as crude turpentine, is distilled with water, the volatile spirit or oil of turpentine passes over, while rosin remains in the still.

858. *State the prominent properties of oil of turpentine.*

A colorless liquid, having a characteristic odor; lighter than water; boiling at 156° (312°.8 F.); readily inflammable, burning with a smoky flame; a solvent for phosphorus, sulphur, india-rubber, and many resins. When exposed to the air, it assumes a yellow tinge, becomes thicker, and absorbs oxygen.

859. *Describe the prominent properties of caoutchouc.*

It is a soft, flexible, yellowish semi-solid, insoluble in water and in alcohol, not acted upon by dilute acids. It has the property of combining with sulphur to produce "vulcanized rubber," a very elastic and impermeable material; and "ebonite" or "hard rubber," a somewhat flexible, although brittle, solid, valuable as an insulating medium.

860. *Describe the prominent properties of gutta percha.*

It is a tough, flexible, but inelastic substance. A good insulating medium, for which purpose it is principally used. It dissolves in chloroform.

861. *What varieties of camphor occur in commerce?*

Borneo camphor, or Borneol, and Chinese or Japanese camphor. The latter contains two atoms of hydrogen less than the former.

862. *State the more prominent properties of Japanese camphor.*

White, semi-transparent crystals, having a strong aromatic odor, and a sharp, bitter taste: very volatile; sparingly soluble in water, readily soluble in alcohol, ether, and the oils.

CARBOHYDRATES.

863. *What are the characters of substances of this class?*

Substances of unknown constitution composed of C, H, and O; the last two being in the proportion to form water, *i. e.*, H_2 to O. But few of them have been obtained artificially, and nearly all exist in vegetable and animal bodies.

864. *Into what three groups may they be divided?*

1. Glucose group. 2. Cane sugar group. 3. Starch group.

865. *Name the most important member of the first group, and give its synonyms.*

Glucose.—Grape sugar; liver sugar; diabetic sugar; dextrose.

866. *State its chief physical properties.*

Forms yellowish nodules or crystals; very soluble in water and in alcohol; has a sweet taste, less marked than that of cane sugar.

867. *How may it be obtained artificially?*

From cane sugar or starch; either, 1, by boiling with a dilute mineral acid; or, 2, by the action of a vegetable ferment, called diastase, which is formed during the germination of grain.

868. *What action have boiling solutions of the alkalies upon glucose?*

They convert it into a brown substance, having the odor of molasses, known as melassic acid.

869. *Is sugar a normal or abnormal constituent of human urine?*

It exists normally in quantities too small to be distinguished by the ordinary tests. Its presence is pathological only when the quantity is so increased that it may be detected by the methods generally used, the gravity of the disorder being proportionate to the quantity of sugar eliminated.

870. *Describe Trommer's test.*

To the urine, in a test-tube, add one or two drops of a solution of cupric sulphate, and then about half as much liq. potassæ as there was urine, shake and boil. If sugar be present, a yellow or red precipitate of cuprous oxide is formed. The presence of albumin interferes with this reaction; if, therefore, the urine be albuminous, it should be heated to the boiling point and filtered before the application of the test. In applying Trommer's or Fehling's test to urine, a dirty yellowish-green color is frequently observed; this is *not* due to the presence of sugar.

871. *Describe Fehling's test.*

Place in a test-tube about 1 cc. Fehling's solution (See Manual, p. 287), and boil; no reddish tinge should be observable. Add the liquid under examination gradually, and boil after each addition. In the presence of sugar a yellow or red precipitate is formed. In the presence of *traces* of glucose, only a small amount of precipitate is produced, which adheres to the glass, and is best seen when the blue liquid is poured out.

872. *Explain the principles upon which Trommer's and Fehling's tests are based.*

By the action of the boiling alkali glucose is converted into substances (glucic and melassic acids) which are very prone to oxidation, and are consequently good reducing agents; if cupric sulphate be present, it is converted into cuprous sulphate, and this in turn decomposed with deposition of cuprous oxide. As there is deoxidation of the copper compound, these tests are spoken of as "reduction tests."

873. *How is the fermentation test conducted?*

Take three test-tubes, A, B, and C, place in each some washed yeast, fill A completely with the urine to be tested, and place it in an inverted position, the mouth below the surface of some of the same urine in a flat vessel (the entrance of air being prevented, during the inversion, by closing the opening of the tube with the finger until it has been brought below the surface of the urine). Fill B completely with some urine to which glucose has been added, and C with distilled water, and invert them in the same way as A; B in saccharine urine, and C in distilled water. Leave all three tubes in a place where the temperature is about 25° (77° F.), for twelve hours, and then examine them. If gas have collected in B over the surface of the liquid, and none in A, the urine is free from sugar. If gas have collected in both A and B, and not in C, the urine contains sugar; if no gas have collected in B, the yeast is worthless, and if any gas be found in C the yeast itself contains CO_2. In the last two cases the process must be repeated with a new sample of yeast.

874. *Describe Robert's method for determining the quantity of sugar in urine.*

The specific gravity of the urine is carefully observed at 25° (77° F.), yeast is then added and the urine maintained at 25° (77° F.) until fermentation has stopped, the sp. gr. is again observed; when it will be found lower than before. Each degree of diminution of sp. gr. represents 0.2196 grms. of sugar in each 100 cc. of urine.

875. *What precaution is to be observed before testing for sugar?*

The urine should first be tested for albumin. If this be present it should be removed by heating the urine to near the boiling point, and filtering from the coagulum.

876. *Under what normal conditions may the urine contain glucose in quantity sufficient to respond to the tests?*

1. In the urine of women during pregnancy and lactation. 2. In the urine of old persons. 3. With a diet rich in starch or sugars.

877. *Under what pathological conditions may the urine contain sugar in considerable quantity?*

1. In abnormally stout persons. 2. In diseases attended with interference of the respiratory function. 3. In diseases attended with interference of the hepatic circulation. 4. In many cerebral and cerebro-spinal diseases. 5. In intermittent and typhus fevers. 6. As a result of the action of carbon monoxide, arsenic, and the anæsthetics. 7. In diabetes mellitus.

878. *What are the characters of urine in diabetes mellitus?*

It is excessive in quantity, pale in color, of high specific gravity, and contains sugar, sometimes as much as 20 to 40 ounces being voided daily.

(See Manual, pp. 283–288.)

879. *Give the formulæ of grape and cane sugars.*

Grape sugar, $C_6H_{12}O_6$; cane sugar, $C_{12}H_{22}O_{11}$.

880. *What are the main points of difference between grape and cane sugars?*

Cane sugar is more easily and perfectly crystallizable, more soluble and sweeter than glucose; it also differs from glucose in not being directly capable of fermentation, and in not reacting with the reduction tests for sugar.

881. *Describe the action of heat on cane sugar.*

When heated to 160° (320° F.) it melts, and, on cooling, forms an amber-colored solid known as "barley sugar." If the heat be continued to 210° (410° F.); a brown tasteless mass, known as "burnt sugar" or "caramel" remains; this is tasteless, soluble in water or dilute alcohol, and is largely used to give color to confectionery and spirits.

882. *Where is milk sugar found? Describe its characters.*

In milk. crystallizes in hard, white prisms. It is the least soluble of all sugars in water, and is insoluble in alcohol; it enters into alcoholic fermentation with difficulty; in presence of decomposing albuminous matter, and under certain other influences, it undergoes a peculiar fermentation, known as the lactic, resulting in the formation of carbon dioxide, alcohol, and lactic acid. It reacts readily with the reduction tests.

883. *Where does starch exist in nature?*

In all plants. The main sources from which it is obtained are potatoes and cereals. It does not exist in animal tissues or fluids.

884. *Give its physical characters.*

It forms a white, shining powder, or, if dried in bulk, columnar masses. When examined microscopically it is found to consist of round, or egg-shaped granules, differing in size and appearance with the source from which it was obtained. When heated, the granules swell and split into concentric layers. Almost insoluble in water, but, if soaked or boiled in water, the granules swell, burst, and finally form a gelatinous mass known as "hydrated starch," or starch paste.

885. *Describe the action of mineral acids on starch.*

When boiled with dilute mineral acids, starch is converted into glucose. Hot concentrated nitric acid converts it into oxalic acid. Cold fuming nitric acid dissolves it, forming an explosive nitro-compound.

886. *Give a test for starch.*

Solution of iodine with starch gives a dark, violet-blue color, which disappears on warming and returns on cooling. This reaction is characteristic and very delicate.

887. *What articles of food are composed entirely of starch?*

Sago, tapioca, arrowroot.

888. *What proportion of starch is contained in wheat and rice?*

Wheat contains about 70 per cent; and rice, 90 per cent.

889. *What action have diastase, ptyalin, and the pancreatic juice upon starch?*

They first convert it into "soluble starch." This is subsequently decomposed into different modifications of dextrin ("erythrodextrin" and "achroödextrin") and maltose. The maltose is more or less completely converted into glucose.

890. *What action has dry heat upon starch?*

The granules are ruptured, and the starch is converted into dextrin.

891. *What action has boiling H_2O upon starch?*

The granules swell and finally burst, forming an opalescent solution of "soluble starch" which becomes gelatinous on cooling.

892. *What is cellulose?*

A substance having the same centesimal composition as starch, and forming the basis of all vegetable fibre. It exists almost pure in cotton and Swedish filter paper.

893. *Give the formula of starch and cellulose.*

$C_6H_{10}O_5$, or a multiple thereof.

894. *Explain the action of nitric acid upon cellulose.*

By acids of different concentration one, two, or three times the group (NO_2) replaces one, two, or three atoms of hydrogen of cellulose, to form mono-, di-, and tri-nitro-cellulose.

895. *How do these three differ, and for what purposes are they used?*

In the violence with which they explode on being ignited in a confined space; the force of the explosion increasing with the number of groups (NO_2) substituted. Trinitro-cellulose is sometimes used as a substitute for gun-powder under the name gun-cotton. Dinitro-cellulose, or pyroxylin, dissolved in a mixture of alcohol and ether, forms the collodion used in photography and as a styptic.

896. *Where is glycogen found, and what are its properties?*

In the liver of all animals. It closely resembles starch in its properties; a white, odorless, tasteless, amorphous powder, swells up in cold water, forms an opalescent solution with hot water; does not react with any of the tests for glucose, into which substance it is, however, readily converted by the same agents which convert starch into glucose, as well as by some substance existing in the liver and in blood.

897. *How is commercial dextrin made, and what are its properties?*

By subjecting starch to a dry heat of 170° 347° (F.); or by heating starch to 90° (194° F.) with dilute H_2SO_4. It is a yellowish-white powder or a yellow solid, resembling gum arabic in appearance. It is soluble in H_2O, forming mucilaginous solutions; insoluble in alcohol. It is not capable of fermentation. It reduces cupro-potassic solutions at 85° (185° F.). Its solutions are dextrogyrous. It is used for the same purposes as gum arabic under the name "British gum."

898. *In what respects do erythrodextrins and achroödextrins differ from each other?*

The former are colored red by iodine, the latter are not. They also differ in their rotary and reducing powers, and in that the former are much more readily converted into sugar than the latter.

AROMATIC SERIES.

899. *Why is this name given to this series?*

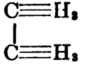
The substances which compose it have strong and aromatic odors; among them are a number of essential oils and substances derived from them.

900. *Of what substances are all the members of this series derivatives?*

Of benzene; C_6H_6.

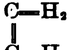
901. *Explain the constitution of benzene, and how the other aromatic substances are derived from it.*

There is a very important difference between the constitution of the aromatic substances and that of those heretofore considered. In the latter, the atoms of carbon are arranged in an open chain, the carbon atoms of which exchange between each other one, two, or three valences:



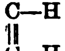
$$\begin{array}{l} C\equiv H_3 \\ | \\ C\equiv H_3 \end{array}$$

Ethyl hydride.



$$\begin{array}{l} C=H_2 \\ \| \\ C=H_2 \end{array}$$

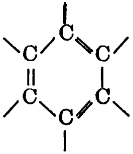
Ethylene.



$$\begin{array}{l} C-H \\ ||| \\ C-H \end{array}$$

Acetylene.

In the case of benzene, however, the carbon atoms are not arranged in an open chain, but in a closed one, the six C atoms alternately exchanging one and two valences,



so that there remain six free valences. When these are all satisfied by hydrogen the resulting substance is benzene. They may, however, be satisfied by other elements or radicals, and all of the aromatic substances, including the hydrocarbons of the fifth and higher series and their derivatives, are derivable from benzene, and contain one or more benzene "nuclei," as the group, C_6, figured above is called.

902. *Whence is benzene obtained, and what are its uses?*

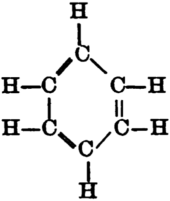
It is obtained, with other hydrocarbons closely related to it, from coal-tar. Its most important use is as the starting-point in the manufacture of aniline dyes. It is also used as a solvent for certain alkaloids.

903. *State its principal properties.*

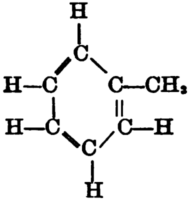
It is a colorless liquid; boils at 80°.5 (176°.9 F.), and solidifies at 4°.5 (40°.1 F.); does not mix with water; burns with a smoky flame. Pure benzene has an agreeable, the commercial article an unpleasant odor.

904. *How are the superior homologues of benzene derived from it?*

By the substitution of $C_nH_{2n} + 1$ for H, thus:



Benzene.



Toluene.

The group (or groups) so substituted is known as a "lateral chain," to distinguish it from the benzene nucleus.

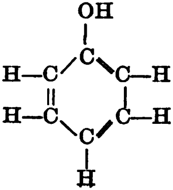
905. *Under what other names is benzene known?*

Benzol. Phenyl hydride.

905*a*. *What substance results from the substitution of a group (OH) for an atom of hydrogen in benzene?*

Phenol. Commonly known as carbolic or phenic acid.

905*b*. *Write the graphic formula of phenol.*



906. *Wherein do the phenols differ from the alcohols?*

They do not furnish aldehydes and acids by oxidation. They are not decomposed into hydrocarbons and water by dehydrating agents. They do not react with acids to produce ethers.

907. *State the properties of phenol.*

It crystallizes in long, colorless needles, which fuse at 35° (95° F.). It has a peculiar odor, and a burning, bitter taste. Soluble in 20 parts of water, quite soluble in alcohol and in ether. It is a powerful antiseptic agent, coagulates albumin, and prevents fermentation.

908. *Describe the analytical reactions of phenol.*

1. Its peculiar odor. 2. Mix with one-quarter volume NH_4HO soln.; add two drops $NaClO$ soln. and warm; a blue or green color, which turns red on addition of HCl to acid reaction. 3. Add two drops of liquid to a little HCl, add one drop HNO_3; a purple-red color. 4. Boil with HNO_3; neutralize with KHO; a yellow, crystalline precipitate. 5. With $FeSO_4$ soln., a lilac color. 6. Float on H_2SO_4, add powdered KNO_3; a violet color.

909. *Describe the symptoms of phenol poisoning.*

Those portions of the skin and mucous membrane which have been in contact with the poison are whitened and hardened. There are burning pains in the mouth, œsophagus, and stomach, and vomiting, lowering of the pulse and temperature, contraction of the pupils, stupor, syncope and collapse, terminating in death. The urine, clear and of the normal color when voided, becomes rapidly greenish, and finally dark olive green or almost black.

910. *What treatment should be adopted in poisoning by phenol?*

The administration of emetics, or the use of the stomach pump, *used with great caution;* albumen (raw white of egg); and stimulation.

911. *How is* picric acid *derived from phenol?*

By boiling phenol with HNO_3, three atoms of H are removed from the former substance and are replaced by three groups $(NO_2)'$, with formation of $C_6H_2(OH)(NO_2)_3$ = trinitrophenol = picric or carbazotic acid.

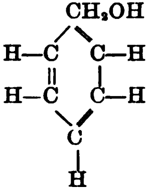
912. *State the properties of trinitrophenol.*

Forms prismatic, sulphur-yellow crystals, very bitter, sparingly soluble in water, quite soluble in alcohol or ether. It is acid in reaction, and forms salts called picrates. These are all decomposed by heat, usually with an explosion. Its coloring power is very intense, and it is used in dyeing.

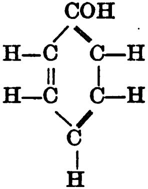
913. *Explain the relations between benzoic alcohol, benzoic aldehyde, and benzoic acid, and give their graphic formulæ.*

Benzoic alcohol is benzene, one of whose H atoms has been replaced by the group CH_2OH, characteristic of the monoatomic alcohols (see Q. 684). Benzoic aldehyde is derivable from it by oxidation, limited to the removal of two H atoms (see Q. 726). Benzoic acid is derivable from benzoic aldehyde or alcohol by more complete oxidation, attended by introduction of an O atom (see Q. 710).

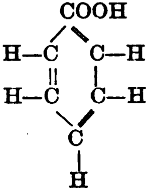
The graphic formulæ are:



Benzoic
alcohol.



Benzoic
aldehyde.



Benzoic
acid.

914. *Of what oil is benzoic aldehyde the chief constituent, and what are its most prominent properties?*

Oil of bitter almonds. It is a colorless oil, sparingly soluble in water, readily converted by oxidizing agents into benzoic acid. It is, *when pure*, non-poisonous, the toxic powers of the commercial oil of bitter almonds being due to the presence of hydrocyanic acid.

915. *How does benzoic acid exist in nature, and how is it obtained?*

It exists in a number of resins and balsams, notably in benzoin, from which it is obtained by sublimation. The benzoin is placed in a porcelain capsule, covered with filter paper, over which is a cone of writing paper. On heating the capsule the acid is volatilized, passes through the filter paper, and condenses in the cone.

916. *State the properties of benzoic acid.*

It crystallizes in long, white, flexible needles, or in thin laminæ, which fuse at 122° (251°.6 F.) and sublime at 145° (293° F.). Sparingly soluble in cold water, more soluble in boiling water, easily soluble in alcohol, ether, and the fatty and ethereal oils. When pure, it is odorless and has a faint acid taste.

917. *Into what substance is benzoic acid converted in passing through the animal economy?*

Hippuric acid.

918. *Give the occurrence and properties of hippuric acid.*

It is found in human urine in small and variable quantities, and abundantly in that of the herbivora. It crystallizes in long, colorless prisms; sparingly soluble in cold, readily soluble in hot water and in alcohol. It is monobasic. When heated alone, when boiled with the mineral acids or alkalies, and under the influence of certain ferments, as in putrid urine, it is decomposed with formation of benzoic acid.

919. *What is the constitution of salicylic acid?*

It has the same relation to phenol that benzoic acid has to benzene. It is therefore phenol in which an atom of hydrogen has been replaced by the group $(CO_2H)'$; $C_6H_4(OH)COOH = C_7H_6O_3$.

920. *How does it exist in nature, and how is it prepared?*

It exists, as its methylic ether, in oil of wintergreen, from which it may be obtained. It is, however, more cheaply prepared by the combined action of sodium and carbonic anhydride upon phenol.

921. *State its properties.*

It crystallizes in colorless prisms; odorless; has a sweetish, sour taste; fuses at 158° (316°.4 F.). At moderately elevated temperatures it sublimes; at higher temperatures, or when rapidly heated, it is decomposed into phenol and carbon dioxide. Sparingly soluble in cold, readily soluble in warm water and in alcohol or ether; its solutions are acid. It is a monobasic acid. It is a valuable disinfectant.

922. *How is gallic acid obtained?*

By exposing moistened gall-nuts to the air for a month or more. Under the influence of a peculiar ferment, the tannic acid of the galls is converted into gallic acid, which is then extracted by subjecting the pasty mass to pressure, and purified by solution, filtration through purified animal charcoal, and crystallization.

923. *Give the principal properties of gallic acid.*

It forms white, silky needles with 1Aq. Odorless, has a sweetish, astringent taste, and an acid reaction; sparingly soluble in cold, readily soluble in hot water, and abundantly soluble in alcohol. It does not precipitate gelatin or the alkaloids from their solutions (distinction from tannin). When heated to 210° (410° F.), it is decomposed into pyrogallol (=pyrogallic acid) and carbon dioxide.

924. *How is* nitrobenzol *obtained, and what relation does it bear to benzene?*

By the action of fuming HNO_3 on benzene, It is benzene in which one H atom has been displaced by NO_2 = $C_6H_5(NO_2)$.

925. *Under what other names is it known, and what are its properties and uses?*

It is known as essence of mirbane, or artificial oil of bitter almonds. It is a yellow, oily liquid, having the odor of bitter almonds; very sparingly soluble in water, but poisonous. It is used as a substitute for oil of bitter almonds, but principally in the manufacture of aniline.

926. *Explain the constitution of aniline and its formation from nitro-benzene.*

It is benzene in which one H is replaced by the group $(NH_2)'$. It may also be considered as phenylamine, *i. e.*, ammonia in which one H has been replaced by the radical phenyl, $(C_6H_5)'$. By the action of reducing agents upon $C_6H_5(NO)_2$, the O_2 is removed, and H_2 substituted: $C_6H_5(NO)_2 + 3H_2 = C_6H_5(N'''H_2)' + 2H_2O$.

927. *Describe the physical properties of aniline.*

When pure, it is a colorless, oily liquid, of a peculiar aromatic odor, boiling at 184°.8 (364°.6 F.), sparingly soluble in water. The commercial product is brown, and has the odor of coal tar.

928. *For what purpose is aniline used in the arts?*

In the manufacture of a great number of brilliant dyes, the most important of which is the red *magenta* or *fuchsine*.

(See Manual, p. 315.)

929. *Is cholesterin related to the fats, and what is its constitution?*

It is not. It is an alcohol, having the composition $\left.\begin{array}{c}(C_{26}H_{43})'\\ H\end{array}\right\} O$.

930. *State the physical characters of cholesterin.*

A white solid, crystallizing in plates or needles; tasteless, odorless, unctuous to the touch, insoluble in water, sparingly soluble in cold alcohol, and readily in hot alcohol or ether. Melts at 145° (293° F.).

931. *Give some of the reactions of cholesterin.*

Treated with HNO_3, the solution evaporated nearly to dryness and NH_4HO added; a brick-red color. With sulphuric acid and chloroform, a red color, changing to violet, blue, green. Not affected by potash solution.

932. *In what parts of the economy does it occur?*

In blood, bile, nerve tissue. Pathologically in gall stones, fluids of hydrocele and of certain cysts. Tumors, consisting almost entirely of cholesterin, have occurred in the brain.

CYANOGEN COMPOUNDS.

933. *What is the composition and valence of the radical cyanogen?*

(CN). Univalent.

934. *Give the formula, proper name, and properties of* cyanogen gas.

$\left.\begin{array}{c}CN\\ CN\end{array}\right\} = (CN)_2$. Dicyanogen. At ordinary temperatures a colorless gas, having a penetrating odor of bitter almonds; very irritating to the eyes and air passages; very poisonous; soluble in water, alcohol, or ether.

935. *Give the formula and synonyms of hydrogen cyanide.*

$\left.\begin{matrix}CN\\H\end{matrix}\right\}$. Hydrocyanic, or prussic acid.

936. *What is the strength of Acid. Hydrocyan. Dil., U. S. P. ?*

Two per cent of anhydrous acid.

937. *What are its characters ?*

A colorless liquid, having an odor of bitter almonds and a bitter taste; very prone to decomposition, especially when exposed to light. Highly poisonous.

938. *What other substances contain hydrocyanic acid ?*

Oil of bitter almonds; bitter almond water; cherry laurel water; wild cherry bark, and the kernels of the peach, plum, etc.

939. *Explain the formation of hydrocyanic acid in oil of bitter almonds.*

It does not pre-exist in the almonds, but is formed by the reaction of two substances known as amygdalin and emulsin (the former does not exist in sweet almonds). This reaction takes place in the preparation of the oil, or, when bitter almonds are eaten, in the mouth and stomach.

940. *Explain the constitution of the cynanides.*

Hydrogen cyanide is an acid, and behaves in a manner similar to hydrochloric acid :

$$HCl + KHO = KCl + H_2O$$

Hydrochloric acid.	Potassium hydrate.	Potassium chloride.	Water.

$$H(CN) + KHO = K(CN) + H_2O$$

Hydrocyanic acid.	Potassium hydrate.	Potassium cyanide.	Water.

941. *State the properties and uses of potassium cyanide.*

Hard, dull white, amorphous solid, having an odor of bitter almonds, and an alkaline taste; very soluble in water, sparingly in alcohol. It is decomposed by even the weak acids, with liberation of hydrocyanic acid, and is consequently very poisonous. It is used largely in photography and in electro-plating.

942. *How is argentic cyanide prepared, and what are its characters?*

By passing hydrocyanic acid through a solution of silver nitrate to saturation, and washing the precipitate. A tasteless, white powder; insoluble in water, but soluble in solution of potassium cyanide.

943. *Explain its use in pharmacy.*

To prepare extemporaneously a solution of hydrocyanic acid of known strength. Take 8.3 grams pure HCl, of sp. gr. 1.16, and dilute with water to make 98 cub. cent., add to this 9.925 grams argentic cyanide; the resulting fluid, separated from the silver chloride by filtration, contains 2 per cent HCN. [The materials must be pure, and the weighings accurate.]

944. *Describe the tests for hydrocyanic acid or a cyanide.*

1. With $AgNO_3$ a white precipitate, soluble in solutions of the cyanides or of the hyposulphites. 2. Add NH_4HS; evaporate to dryness; add Fe_2Cl_6 solution, a red color. 3. Add KHO solution and then solution of $FeSO_4$ containing $(Fe_2)(SO_4)_3$: a green precipitate, which forms a blue solution with HCl. 4. Moisten filter paper with freshly prepared tincture of guaiac, dip the paper into very dilute solution of $CuSO_4$ and, after drying, moisten with the solution to be tested; a deep blue color.

945. *Describe the symptoms of hydrocyanic acid poisoning.*

Its action is always rapid. Relatively small doses cause an immediate sense of constriction of the throat, followed in one to two minutes by sense of pressure in the head, vertigo, confusion of intellect and loss of muscular power. The pulse is quick, the respiration slow and stertorous. Tetanic convulsions and involuntary discharges of urine and fæces occur, followed by paralysis. Death follows in from two hours to two days, from asphyxia. When large doses are taken no subjective symptoms are observed. The patient loses consciousness in less than one minute. There is a short convulsive seizure, usually accompanied by evacuations of fæces, after which the patient lies perfectly still with no sign of life save an almost imperceptible pulse and infrequent, spasmodic respiratory efforts, in which inspiration is short and expiration protracted. Death follows in from five to twenty minutes.

946. *What treatment should be followed in poisoning by hydrocyanic acid?*

There is no time for administration of antidotes. The patient should be stripped, and cold water dashed upon the head and spine, which are then rubbed dry with warm towels and the cold douche repeated, after which artificial respiration should be practised. Inhalations of chlorine or ammonia, largely diluted with air, are recommended.

947. *What substances other than hydrocyanic acid cause cyanic poisoning?*

Potassium cyanide, mercuric cyanide, bitter almonds in sufficient quantity, oil of bitter almonds, and cherry-laurel water.

SUBSTANCES WHOSE CONSTITUTION IS UNKNOWN.

GLUCOSIDES.

948. *What is the characteristic property of the glucosides?*

That of splitting up under the influence of the acids, alkalies, and of certain ferments into a sugar (usually glucose) and some other substance.

949. *Mention some of the more important glucosides, and the sources from which they are obtained.*

Amygdalin from bitter almonds; digitalin, digitonin, digitaleïn, and digitoxin from digitalis; jalapin from scammony; convolvulin from jalap; salicin from willow bark; santonin from artemisia; solanin from dulcamara.

950. *Describe the prominent symptoms of poisoning by digitalis.*

Nausea, and occasionally vomiting. Sometimes colic and diarrhœa. After two or three hours, marked diminution in the frequency of the pulse, which may fall to 40 or even 25. Dyspnœa, attended by a sense of oppression in the chest and coldness of the extremities. Headache, vertigo, and tendency to sleep.

Usually attacks of syncope occur, provoked sometimes by the slighest movement of the patient. Death is generally by syncope, sometimes after several hours of coma succeeded by convulsions.

951. *What treatment should be adopted in poisoning by digitalis?*

The patient must be kept strictly in the recumbent position. The stomach should be washed out with infusion of tea by the stomach pump or siphon. Stimulants should be given.

952. *Give a test for the presence of digitalin.*

Dissolve in concentrated H_2SO_4, a green color is produced; stir the solution with a glass rod moistened with bromine water, the color changes to reddish-violet; if the mixture be shaken with ether, the coloration passes into the ethereal layer.

953. *What are the* tannins *or* tannic acids?

Substances of different composition existing in various barks, leaves, etc. They are amorphous bodies, having a faintly acid reaction, soluble in H_2O and astringent. They all precipitate with albumin, the alkaloids, the ferric salts, and they also form with animal substances imputrescible compounds. They exist notably in oak bark, gall-nuts, cinchona, coffee. They are, with one possible exception, glucosides.

954. *Whence is the acidum tannicum, U. S. P., obtained, and what are its chemical name and formula?*

From nut-galls, which are excrescences produced upon the oak by the puncture of an insect. It is known as gallotannic acid. It has the formula $C_{14}H_{10}O_9$, and is considered as being formed by the union of two molecules of gallic acid with loss of a molecule of water :

$$\underset{\text{Gallic acid.}}{2C_7H_6O_5} = \underset{\text{Water.}}{H_2O} + \underset{\text{Gallotannic acid.}}{C_{14}H_{10}O_9}$$

955. *Give the prominent properties of gallotannic acid.*

A light, yellowish, amorphous powder, highly astringent. Readily soluble in H_2O, less so in alcohol, insoluble in ether. It has acid properties, and forms salts which are amorphous.

956. *What class of medicinal substances contain tannin ?*

The vegetable astringents.

957. *Why are the alkaloids and tartar emetic incompatible with tannic acid ?*

Because insoluble tannates are formed.

958. *What is formed when tannic acid and a ferric compound are brought together ?*

Black ink.

ALKALOIDS.

959. *What is an alkaloid ?*

An organic, nitrogenized substance, alkaline in reaction, and capable of combining with acids to form salts, in the same way as does ammonia. They are sometimes known as vegetable bases or alkalies.

960. *Into what two classes are the alkaloids divided ; and wherein do they differ ?*

Volatile and fixed. The volatile alkaloids are oily, readily volatile without decomposition, and consist of C, H and N. The fixed alkaloids are for the most part solid and crystalline, not or only partially volatile without decomposition, and consist of C, H, N and O.

961. *Describe the behavior of the alkaloids and of their salts toward solvents.*

As a rule, the free alkaloids are insoluble or very slightly soluble in water, more soluble in chloroform, petroleum-ether, benzene, and amylic alcohol. Their salts are insoluble in the last-named solvents, but generally soluble in water and in alcohol.

962. *How should the names of the alkaloidal salts be constructed?*

In the same way as those of the corresponding ammoniacal salts: Thus, as ammon*ia* combines with hydrochloric acid to produce ammon*ium* chloride; so morph*ia* (or morphine) combines with the same acid to produce morph*ium* chloride.

963. *Describe some of the* general reactions *of the alkaloids.*

They are precipitated from solutions of their salts by KHO, NaHO, NH_4HO, CaH_2O_2, BaH_2O_2 and MgO. Their solutions form yellowish or white precipitates with solutions of phosphomolybdic acid, potassium iodhydrargyrate, and other "general reagents."

964. *Name the principal volatile alkaloids.*

Nicotine, coniïne, sparteïne.

965. *Whence is coniïne obtained, and what are its properties?*

From hemlock, Conium, U. S. A colorless, oily liquid, lighter than H_2O, having a disagreeable, penetrating odor; sparingly soluble in H_2O, readily in alcohol and ether. It has a strongly alkaline reaction and forms neutral, amorphous salts with most acids; it deteriorates rapidly on exposure to air, becomes colored, and finally resinous.

966. *Describe the prominent symptoms of poisoning by hemlock or its alkaloid.*

The action of the plant begins in a half-hour or less, that of the alkaloid almost immediately. There are headache, derangement of vision, with dilated and fixed pupils, interference with deglutition and great drowsiness. Muscular weakness, increasing to paralysis, begins at the extremities and extends to the muscles of respiration, causing death by apnœa in from one to three hours.

967. *What treatment should be followed?*

The unabsorbed poison is to be removed by the pump or emetics. Stimulants are indicated, and the performance of artificial respiration.

968. *Give the source and properties of nicotine.*

It is obtained from tobacco. It is an oily, colorless, transparent liquid, heavier than water, having a burning taste and a faint odor of tobacco, which becomes more powerful upon the application of heat; it is quite volatile, and its vapors are very irritating. Very soluble in water, alcohol, and ether. When exposed to the air it absorbs moisture, becomes brown and is oxidized. It is very alkaline, and forms well-defined salts with acids. It is a very violent poison, and very rapid in its action.

970. *Describe the prominent symptoms of poisoning by tobacco or nicotine.*

The alkaloid has caused death in three minutes, tobacco in fifteen minutes. The patient first suffers from giddiness, trembling of the limbs, depression, cold sweats, and confusion of intellect. The pulse gradually becomes weaker, the respiration more difficult, and paralysis more extended. Death is usually preceded by convulsions.

971. *What should be the treatment in nicotine or tobacco poisoning?*

Wash out the stomach with water or infusion of tea holding charcoal in suspension, opium, stimulants.

OPIUM ALKALOIDS.

972. *Name the principal alkaloids existing in opium.*

Morphine, codeïne, narceine, narcotine, thebaïne, papaverine.

973. *In what form do these probably exist in opium?*

In combination with a peculiar organic acid known as meconic acid, or with lactic acid.

974. *State the properties of morphine.*

It crystallizes in colorless, transparent, odorless prisms, having a persistent, bitter taste; soluble in 500 parts of boiling water, insoluble in ether and chloroform, soluble in 13 parts of boiling alcohol. Morphine and its salts are very prone to oxidation.

975. *What salts of morphium are officinal?*

The acetate, chloride, and sulphate.

976. *Give tests for the presence of morphine.*

1. It is colored red, changing to yellow, by HNO_3. 2. If iodic acid and a drop of chloroform be added to solution of a morphine salt, free iodine is liberated, which colors the chloroform violet. If now dilute NH_4HO be floated on the liquid, a dark brownish zone is formed. 3. Neutral solution of Fe_2Cl_6 gives a blue color with morphine. 4. Add dilute solution of Fe_2Cl_6 to solution of potassium ferricyanide; the yellowish mixture is turned blue by morphine. 5. Heat morphine with concentrated H_2SO_4 to 200° (392° F.), add a drop of the liquid cautiously to water; a blue solution is formed, which communicates its color to chloroform, when shaken with that liquid.

977. *What relation does apomorphine bear to morphine, and how is it produced?*

It is morphine, minus H_2O. It is produced by heating morphine with HCl to 150° (302° F.) under pressure.

978. *Give a test for the presence of meconic acid.*

With a *neutral* solution of Fe_2Cl_6 a red color is produced, which is *not* discharged upon the addition of mineral acids or of solution of $HgCl_2$.

979. *How much morphine does opium contain?*

10 to 15 per cent.

980. *Which is the most actively poisonous of the opium alkaloids?*

Thebaïne.

981. *Describe the prominent symptoms of poisoning by opium and its preparations.*

At first there is usually a period of excitation, marked by restlessness, great physical activity, loquacity and hallucinations. The patient then becomes weary, dull, and drowsy; he yields to the desire for sleep, from which at first he may be aroused. The lips are livid, the face pale, the pupils contracted, and the surface bathed in perspiration. The condition of somnolence rapidly passes into narcosis. The patient cannot be roused, and lies motionless and senseless, with completely relaxed muscles. The pulse, at first full and strong, becomes feeble, slow, irregular and easily compressible; the respiration slow, shallow, stertorous and accompanied by mucous râles. The patient rapidly becomes comatose and, in fatal cases, dies in from 45 minutes to 56 hours, usually in from 12 to 18 hours. In cases of recovery after the stage of narcosis, the pulse and respiration gradually become more normal, and the condition of coma passes into one of deep sleep, lasting 24 to 36 hours.

982. *What treatment should be followed in opium poisoning?*

Unabsorbed poison is to be removed by washing the stomach with infusion of tea containing powdered charcoal, or by emetics of zinc sulphate or of apomorphine. The patient is to be kept in motion to prevent sleep. Cold affusions. Artificial respiration.

CINCHONA ALKALOIDS.

983. *Name the two most important alkaloids of cinchona bark.*

Quinine and cinchonine.

984. *With what peculiar acid are they combined in nature?*

Kinic acid.

985. *State the physical properties of quinine.*

A light, white, amorphous powder, without odor, having a persistent, bitter taste and an alkaline reaction. Very sparingly soluble in water, readily soluble in alcohol, chloroform, and ether. It separates on evaporation of its alcoholic or ethereal solution in crystals containing 3Aq.

986. *Explain the solubility of quinine in dilute H_2SO_4.*

The quinine combines with the acid to form the bisulphate, which is soluble.

987. *What salt of quinium is commonly used in medicine, and what are its physical properties?*

The sulphate. It crystallizes in thin, light white needles, with 7Aq; sparingly soluble in H_2O, readily in boiling alcohol and in ether. It dissolves readily in dilute H_2SO_4, the soluble bisulphate being formed. Solutions of this salt, although they are colorless by transmitted light, present beautiful pale blue reflections.

988. *By what reactions may quinine be recognized?*

1. By the blue reflections (fluorescence) of its solution in dilute H_2SO_4. 2. When chlorine water and aqua ammoniæ are added to quinine solution it assumes a green color. 3. A deep red color is produced in solutions of quinine when chlorine water, potassium ferrocyanide, and aqua ammoniæ are added in the order named.

989. *How is quinine adulterated?*

With gypsum, stearic acid, starch, salicin, and cinchonium sulphate.

990. *How may the presence of mineral substances be detected?*

By heating to redness; if any mineral matter be present it remains after heating, while pure quinine is entirely volatilized.

991. *How is the presence of cinchonine detected?*

Place a gram of the sample in a test-tube; add 10–15 grams of ether and 2 grams of aqua ammoniæ, shake, and allow the mixture to separate into two layers; if cinchonine be present it will appear as a precipitate in the lower layer.

992. *How may the other adulterations named be detected?*

Stearic acid may be detected by its insolubility in dilute H_2SO_4; starch by its insolubility in boiling alcohol; and salicin by the red color produced upon the addition of H_2SO_4.

STRYCHNOS ALKALOIDS.

993. *What two important alkaloids belong to this class?*

Strychnine and brucine.

994. *Give the properties of strychnine.*

It crystallizes in small, transparent, four-sided prisms; odorless, having an intensely bitter taste and an alkaline reaction; very sparingly soluble in water, soluble in benzene, chloroform, and boiling dilute alcohol, insoluble in absolute alcohol, ether, and solutions of the alkalies. It is a strong base, neutralizing acids and forming salts, most of which are crystalline, soluble in water and very bitter.

995. *Describe the tests for strychnine.*

1. The alkaloid forms a colorless solution with concentrated H_2SO_4. If a crystal of potassium dichromate be drawn through this solution, it is followed by a track of color which is first (for an instant) blue, then violet, then rose colored, and finally yellow. 2. The alkaloid and its salts are intensely and persistently bitter. 3. Injected into a lymph pouch of a frog, it causes violent tetanic spasms and opisthotonos.

996. *Describe the prominent symptoms of strychnine poisoning.*

The action of the poison is usually rapid. The characteristic symptoms are tetanic spasms with opisthotonos, sometimes emprosthotonos or pleurosthotonos. The pain is intense, and the patient suffers from thirst and is in apprehension of death. The spasms increase in frequency and in duration, and when death follows it is either during a spasm by paralysis of the muscles of respiration, or in an interval from exhaustion.

997. *What treatment should be followed in poisoning by strychnine?*

Unabsorbed poison is to be removed as directed in opium poisoning, and the convulsions are to be arrested or mitigated by bringing the patient under the influence of choral or chloroform as rapidly as possible. The patient is to be kept as quiet as possible.

998. *Give a test for brucine.*

Upon the addition of HNO_3 a bright red color is produced, which gradually turns to yellow on the addition of stannous chloride, or to reddish-violet on the addition of ammonium sulphydrate.

OTHER ALKALOIDS.

999. *Whence is atropine obtained?*

From belladonna.

1000. *What are its characters?*

It crystallizes in silky needles, having a faint yellowish tinge and persistent, bitter taste; odorless; sparingly soluble in water, readily in alcohol.

1001. *What salt of atropium is used in medicine?*

The sulphate.

1002. *Describe the prominent symptoms of poisoning by atropine or belladonna.*

Giddiness, drowsiness, great thirst, dryness of the mouth and fauces, and difficulty in deglutition. The pulse is stronger than normal, the countenance is flushed, the eyes sparkling and prominent, with widely dilated pupils and disturbances of vision. The power of articulation is lost early. The extremities are the seat of partial paralysis, preceded by numbness. Later, there is delirium, sometimes maniacal, sometimes attended with pleasing hallucinations or spectral illusions. In fatal cases, the patient passes into a condition of coma terminating in death. In cases of recovery, the patient sleeps quietly and awakes unconscious of pre vious mental disturbances.

1003. *How should cases of poisoning by this and other alkaloids be treated?*

The chief indication is to remove any portion of the poison remaining in the stomach, as rapidly as possible; an emetic of sulphate of zinc should be given, or, if this be not feasible, a hypodermic injection of apomorphia. The stomach-pump should be used and the stomach washed out with infusion of tea, or with water holding powdered animal charcoal in suspension. Chemical antidotes are of little value. Where physiological antidotes exist they should be used.

1004. *Name the principal alkaloids of aconite.*

Aconitine, napelline, and lycoctonine.

1005. *Describe the prominent symptoms of aconite poisoning.*

Numbness and tingling, first of the mouth and fauces, later becoming general; a sense of dryness and constriction in the throat; persistent vomiting; diminished sensibility; great muscular feebleness; loss of speech; irregularity and failure of the heart's action; death by syncope.

1006. *What are the ptomaïnes?*

Alkaloids produced from animal substances by putrefaction or by morbid processes.

See Manual, p. 348.

ALBUMINOUS SUBSTANCES.

1007. *State the general properties of albuminous substances.*

They are nitrogenized bodies, not capable of crystallization, having, when dry, the appearance of gum arabic, odorless, insipid; insoluble in ether and alcohol. Their solubility in water varies according to the temperature and the presence or absence of alkalies, acids and mineral salts. They enter very readily into the series of changes designated by the term putrefaction. Their chemical composition is not constant, and they are probably mixtures of undetermined substances.

See Manual, p. 345.

1008. *What conditions are necessary to putrefaction?*

The presence of air and water, and a temperature between 5° and 90° (41°-194° F.).

1009. *What are* antiseptics, deodorizers *and* disinfectants?

Antiseptics are substances which arrest or restrain putrefaction. Deodorizers (or air purifiers) are substances which destroy the odorous products of putrefaction. Disinfectants are substances which restrain infectious diseases by destroying their specific poisons.

1010. *What is understood by coagulation?*

The property of albuminous substances of being converted into insoluble modifications by the action of heat, mineral acids, alcohol, and certain metallic salts. When once converted into these modifications, the albuminoids will not return to their primitive form.

1011. *Give reactions for the detection of albuminous substances.*

1. They are dissolved by boiling HCl, the solution being violet-red in color. 2. They turn yellow when warmed with concentrated HNO_3. 3. Iodine produces a brown stain in the cold. 4. Solution of mercuric nitrate with excess of nitric acid (Millon's reagent) gives a fine, red color when warmed with an albuminous substance. 5. With Pettenkofer's reaction, the same result is obtained as with the biliary salts.

1012. *To what substance is the name* albumen *applied, and how may it be distinguished from "serum albumin"?*

To an albuminoid substance existing in the white of egg, coagulable by heat, upon the addition of HNO_3, or upon being shaken with ether. Serum albumin is not affected by ether.

1013. *Where does serum albumin exist in the animal body?*

In the blood serum, lymph, chyle, pericardial fluid, the fluids of cysts and transudations, and pathologically in the urine.

1014. *How is the sp. gr. of the urine affected by the presence of serum albumin?*

It is lowered.

1015. *Why should the urine be tested for albumin before examining for sugar?*

Because albumin interferes with the tests for sugar. If present, it must therefore be removed before examining for sugar. (See Q. 875.)

1016. *How is urine tested for albumin?*

By the action of heat and of nitric acid; both tests must be used, as neither is of itself conclusive.

1017. *Describe the heat test?*

The reaction is first observed. If it be acid the urine is simply heated to near the boiling-point; if the urine be neutral or alkaline, it is rendered *faintly* acid by the addition of acetic acid, and heated. If albumin be present, a coagulum is formed, varying in quantity from a faint cloudiness to entire solidification, according to the quantity of albumin present. The coagulum is not redissolved upon the addition of HNO_3.

1018. *What are the sources of error to be avoided?*

Albumin is slightly soluble in alkaline liquids; the urine is therefore rendered acid to prevent small quantities of albumin remaining in solution upon the application of heat, and thus escaping detection. Albumin is also slightly soluble in dilute HNO_3, therefore acetic acid is used. The phosphates, in faintly acid urine, are held in solution largely by the presence of carbonic acid; when the urine is heated, this is driven off, and the phosphates may be precipitated in a form closely resembling albumin; to remove this source of error HNO_3 is added after heating. It dissolves the phosphates, but does not affect the albumin. Nitric acid cannot be used alone as a test for albumin, because, if the urine contain an excess of urates, these are decomposed upon the addition of acid, and the almost insoluble uric acid is precipitated, and might easily be mistaken for albumin.

1019. *How may minute traces of albumin be detected?*

Place in a test-tube a layer of HNO_3 about 2 centim. in thickness; then, with a pipette, carefully float upon the surface of this a layer of the urine in such a manner that the liquids do not mix; if albumin be present, a cloudy ring appears *at* the point of junction of the two layers, the borders of the cloud being sharply defined. A cloudy ring may be formed by the presence of an excess of urates, but in this case it is not *at*, but *above* the point of junction of the layers, and its upper border is not sharply defined, but fades off gradually.

1020. *Give a process for determining the quantity of albumin in urine.*

Heat a known volume of acid urine to near the boiling point; collect the coagula upon a weighed filter, wash with water, dry the filter with adhering albumin at 100° (212° F.), weigh. The difference between the two weighings indicates the quantity of dry albumin in the volume of urine used. [Some authors direct to weigh the filter and albumin wet; when this is done, there is no approach to accuracy, as it is impossible to judge how much water is being weighed.]

1021. *Why should albuminous urine always be examined microscopically?*

To determine the presence or absence of blood or pus-corpuscles, spermatozoa, and casts. When the urine contains blood, pus, or spermatic fluid, it is always slightly albuminous. The presence of albumin has then no clinical importance beyond that attaching to the fluids named. Casts are never present in the urine of persons free from organic disease of the kidneys.

1022. *State the characters of fibrin.*

White, elastic filaments interlaced in all directions, insoluble in water. When treated with dilute acids, it swells and gradually dissolves, although usually incompletely.

1023. *Does fibrin pre-exist in the blood?*

No; it is formed at the time of separation.

1024. *Explain its formation.*

There exist in the plasma two albuminous substances known as paraglobulin and fibrinogen, the former being greatly in excess of the latter. Under proper conditions, these two substances unite with each other to form fibrin. When all the fibrinogen of the blood has been converted into fibrin, no further coagulation will take place, unless upon the addition of a further quantity of fibrinogen, which then unites with the remaining paraglobulin to form another quantity of fibrin.

1025. *What peculiar albuminous substance exists in milk, and what are its properties?*

Casein. An amorphous, white substance, tasteless and odorless, very soluble in alkaline fluids. Coagulates with acids, and under the influence of infusion of *rennet* (mucous membrane of fourth stomach of calf), but not by heat.

1026. *Into what substance are all the albuminous bodies converted by the action of the gastric juice?*

Into albuminose or peptone.

1027. *By what constituents of the gastric juice is this change brought about?*

By the combined action of the free acid and a substance, known as pepsin, peculiar to the gastric juice. Neither pepsin nor an acid will produce the change alone.

1028. *In what important point does albuminose differ from other albuminous substances?*

In being capable of dialysis, *i. e.*, passing through animal membranes, which other albuminous substances are incapable of. It is in the form of albuminose that the food elements of this class pass from the intestine into the blood.

1029. *Whence is gelatin obtained, and how?*

From bones, tendons, fish bladders, skins, etc. These tissues contain a peculiar substance, called collagen, in combination with mineral and other matters. When collagen is heated with water, under such pressure that the temperature reaches 106° (222°.8 F.), a solution is formed which, on cooling, solidifies to a jelly. This jelly contains a new substance, gelatin, glue, isinglass, or size, according to the substances used and the peculiarities of the manufacturing process followed.

ANIMAL CRYPTOLYTES, OR FERMENTS.

1030. *What are the characters of substances of this class?*

They are nitrogenized bodies, in some respects resembling the albuminoids, which have the power to provoke changes in other organic substances in some way as yet imperfectly understood.

1031. *What cryptolyte exists in the saliva, and what is its action?*

Ptyalin. It has the property of changing starch into sugar in a liquid of alkaline reaction.

1032. *What cryptolyte exists in the gastric juice, and what is its principal action?*

Pepsin. In the presence of a free acid (best HCl), it converts albuminous substances into albuminose.

1033. *What cryptolytes exist in the pancreatic secretion, and what are their actions?*

1. Trypsin, which converts albuminous substances into albuminose in alkaline liquids. 2. A diastatic cryptolyte, converting starch into maltose and glucose. 3. Some substance capable of emulsifying and saponifying the fats.

ANIMAL COLORING-MATTERS.

1034. *By what names is the coloring-matter of the blood known?*

Hæmoglobin, hæmatocrystallin, and cruorin; the first is the name now in general use.

1035. *In what portion of the blood does it exist?*

In the corpuscles.

1036. *What are its physical properties?*

It is, when pure, a crystalline solid, more or less soluble in water, soluble in dilute alcohol and in dilute solutions of the alkalies; not capable of dialysis, although crystalline. Red or purple in color.

1037. *How does hæmoglobin from the blood of different kind of animals differ in physical properties?*

In the facility with which it forms crystals and in the form of the crystals. In its solubility; the crystals from the blood of the ox are very readily soluble in water, while those from the blood of the raven are almost insoluble in that fluid.

1038. *Of what elements is hæmoglobin composed?*

C, H, N, O, S, and Fe.

1039. *What is the object of administering iron in anæmia?*

To furnish one of the important constituents of the corpuscles, which are deficient in this condition.

1040. *Explain the change which hæmoglobin undergoes in passing through the lungs.*

Hæmoglobin exists in the blood in two different conditions of oxidation, which are designated by the names oxyhæmoglobin and reduced hæmoglobin; the latter contains the less quantity of oxygen, and exists in venous blood. As the blood circulates in the lung, it is separated from the air in the air cells by a very thin membrane through which the oxygen passes into the blood: it enters into a peculiar, loose chemical combination with the coloring-matter to form oxyhæmoglobin.

1041. *What changes does oxyhæmoglobin undergo in the capillary circulation, and what is its function?*

The opposite change occurs to that which takes place in the pulmonary circulation; the oxyhæmoglobin is decomposed, oxygen passes into the tissues, and reduced hæmoglobin returns by the venous system to the lungs to receive a fresh supply of oxygen. The coloring-matter is, therefore, the carrier of oxygen from the air to the tissues.

1042. *How may the two conditions of hæmoglobin be distinguished by the spectroscope?*

Solutions of oxyhæmoglobin present two absorption bands, between the solar lines D and E; that nearer D being narrower, sharper, and darker than that nearer E. Solutions of reduced hæmoglobin, on the other hand, show a single broad band occupying about the space left bright between the oxyhæmoglobin bands and more faint and ill-defined than either of those.

1043. *What action has carbon monoxide on oxyhæmoglobin?*

It drives out all of the loosely combined oxygen, and forms, with the reduced hæmoglobin, a compound which is much more stable than oxyhæmoglobin, and from which the carbon monoxide cannot be again displaced by oxygen.

1044. *What is hæmatin?*

An uncrystallizable coloring-matter formed by the decomposition of hæmoglobin.

1045. *How may hæmoglobin be detected in the urine?*

1. By spectroscopic examination (see Q. 1042). 2. To a few drops of the urine in a test-tube add a drop of a freshly prepared tincture of guaiacum and a little ozonic ether (or turpentine), and shake; a blue color is produced.

1046. *Name the principal coloring-matters of the bile.*

Bilirubin and biliverdin.

1047. *State the properties of bilirubin.*

It forms microscopic, orange, or brick-red crystals, soluble in chloroform or benzene, insoluble in water, ether, alcohol, and dilute acids, soluble in dilute alkalies. When acted upon by oxidizing agents, it is converted into biliverdin.

1048. *Describe Gmelin's reaction for bile pigments as applied to the urine.*

Put 3 cc. HNO_3 in a test-tube, add a piece of wood, and heat until the acid is yellow; cool. When cold, float some of the urine to be tested upon the surface of the acid. A green band is formed at the junction of the liquids, which gradually rises, and is succeeded from below by blue, reddish-violet, and yellow.

1049. *How should urine be examined for color?*

It should be acidulated with HCl, and allowed to stand for four hours, after which it should be placed in a beaker of about three inches diameter, and the color observed by transmitted light.

1050. *Describe how the color may vary physiologically.*

The greater the quantity of urine the lighter the color, as a rule. The morning urine is darker than that voided at other times, and the use of animal food also produces a high-colored urine. The use of certain drugs communicates a peculiar color to the urine: rhubarb, bright yellow; senna, brownish; logwood, reddish; santonin, orange-red or golden-yellow.

1051. *Under what pathological conditions is the urine pale?*

Under those conditions which produce an increase in the quantity, and in anæmia. In the latter condition the quantity is not increased.

1052. *Under what conditions is it high colored?*

Under those conditions in which the quantity of water eliminated by the kidneys is diminished, while the elimination of the solids remains normal, or is increased; such urines have a high specific gravity, and are strongly acid. As the coloring matter of the urine is a product of the disassimilation of hæmoglobin, an absolute increase in the quantity of urine-pigment eliminated indicates an increased destruction of blood-corpuscles.

NOTE.—A comparatively light-colored urine is frequently found, on addition of acid, to contain a large quantity of coloring-matter, which, before the action of the acid, was in the form of a colorless combination.

1053. *To what do brown and black urines owe their color?*

To the presence of abnormal coloring-matters, blood or bile.

APPENDIX.

A.

ELEMENTS.

Aluminium	Al	27
Antimony	Sb	120
Arsenic	As	75
Barium	Ba	137
Bismuth	Bi	206.5
Boron	B	11
Bromine	Br	80
Cadmium	Cd	112
Cæsium	Cs	133
Calcium	Ca	40
Carbon	C	12
Cerium	Ce	141
Chlorine	Cl	35.
Chromium	Cr	52.5
Cobalt	Co	59
Copper	Cu	63.5
Didymium	D	144.8
Erbium	E	166
Fluorine	F	19
Gallium	Ga	69
Glucinum	Gl	9
Gold	Au	196
Hydrogen	H	1
Indium	In	113.4
Iodine	I	127
Iridium	Ir	193
Iron	Fe	56
Lanthanium	La	138.5

Lead	Pb	207
Lithium	Li	7
Magnesium	Mg	24
Manganese	Mn	54
Mercury	Hg	200
Molybdenum	Mo	96
Nickel	Ni	58
Niobium	No	94
Nitrogen	N	14
Osmium	Os	199
Oxygen	O	16
Palladium	Pd	106
Phosphorus	P	31
Platinum	Pt	194.4
Potassium	K	39
Rhodium	Rh	104
Rubidium	Rb	85.5
Ruthenium	Ru	104
Scandium	Sc	44
Selenium	Se	78.8
Silicon	Si	28
Silver	Ag	108
Sodium	Na	23
Strontium	Sr	87.5
Sulphur	S	32
Tantalum	Ta	182
Tellurium	Te	128
Thallium	Tl	204
Thorium	Th	234
Tin	Sn	118
Titanium	Ti	50
Tungsten	W	184
Uranium	U	238.5
Vanadium	V	51.5
Ytterbium	Yb	172.7
Yttrium	Y	89.8
Zinc	Zn	65
Zirconium	Zr	89.5

B.

MEASURES AND WEIGHTS.

I.

Measures of length.

1 Kilometre = 1000 metres. | 1 Millimetre = 0.001 metre.
1 Hectometre = 100 " | 1 Centimetre = 0.01 "
1 Decametre = 10 " | 1 Decimetre = 0.1 "

1 **Metre** = Unity.

1 Kilometre = 0.6214 mile. | 1 Centimetre = 0.3937 inch.
1 Metre = 3.2809 feet. | 1 Millimetre = 0.0394 "

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1 Foot = 30.48 centimetres. | 1 inch = 2.54 centimetres.

Weights.

1 Kilogram = 1000 grams. | 1 Milligram = 0.001 gram.
1 Hectogram = 100 " | 1 Centigram = 0.01 "
1 Decagram = 10 " | 1 Decigram = 0.1 "

1 *Gram.*

1 Kilogram = 2.6792 lbs. Troy. | 1 Gram = 15.434 grains.

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1 Grain = 0.065 gram. | 1 Dram = 3.888 grams.
1 Scruple = 1.296 grams. | 1 Ounce = 31.103 "
1 Pound = 373.19 grams.

Measures of volume.

1 Cubic metre = 1000 litres.
1 Cubic centimetre = 0.001 litre.
1 Litre = 1 cubic decimetre.
1 Litre = 1.0567 quarts. | 1 cc. = 0.061 cubic inch.

1 Minim = 0.0614 cc.
1 Fluid dram = 3.689 "
1 Fluid ounce = 29.518 cc.
1 Pint = 472.208 "

To convert thermometric scales.

Centigrade into Fahrenheit:

$$\frac{\text{Cent.} \times 9}{5} + 32 = \text{Fah.}$$

Fahrenheit into Centigrade:

$$\frac{\text{Fah.} - 32}{9} \times 5 = \text{Cent.}$$

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